NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

UNDERSTANDING RETURN ON INVESTMENT FOR DATA CENTER CONSOLIDATION

by

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September 2013

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704–0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202–4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704–0188) Washington, DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** September 2013	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE UNDERSTANDING RETURN ON INVESTMENT FOR DATA CENTER CONSOLIDATION		**5. FUNDING NUMBERS**	
6. AUTHOR(S) Scott A. Humr			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943–5000		**8. PERFORMING ORGANIZATION REPORT NUMBER**	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A		**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB Protocol number ____N/A____.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited		**12b. DISTRIBUTION CODE** A	

13. ABSTRACT (maximum 200 words)

The federal government has mandated that agencies consolidate data centers in order to gain efficiencies and cost savings. It is a well-established fact that both public and private organizations have reported considerable cost savings from consolidating data centers; however, in the case of federal agencies, no established methodology for valuing the benefits has been delineated. Nevertheless, numerous federal policies mandate that investments in IT demonstrate a positive return on investment (ROI). The problem is that the Department of Defense does not have clear instructions on how to measure ROI in order to evaluate an opportunity to consolidate data centers. While calculating ROI for IT can be very challenging, most private and public firms have methods for demonstrating a return ratio and not only cost savings. Therefore, choosing metrics and methodologies for calculating ROI is an important step in the decision-making process. This complexity complicates estimating a data centers' utility and the true value generation of merging data centers. This thesis will explore the challenges that the Marine Corps' faces for calculating ROI for data center consolidation.

14. SUBJECT TERMS DoD, Stakeholder Based Value Model, MCICOM, MCI-W, Data Center Consolidation (DCC), Return on Investment (ROI), FDCCI, Marine Corps	**15. NUMBER OF PAGES** 95
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540–01–280–5500 Standard Form 298 (Rev. 2–89)
Prescribed by ANSI Std. 239–18

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UNDERSTANDING RETURN ON INVESTMENT FOR DATA CENTER CONSOLIDATION

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

The federal government has mandated that agencies consolidate data centers in order to gain efficiencies and cost savings. It is a well-established fact that both public and private organizations have reported considerable cost savings from consolidating data centers; however, in the case of federal agencies, no established methodology for valuing the benefits has been delineated. Nevertheless, numerous federal policies mandate that investments in IT demonstrate a positive return on investment (ROI). The problem is that the Department of Defense does not have clear instructions on how to measure ROI in order to evaluate an opportunity to consolidate data centers. While calculating ROI for IT can be very challenging, most private and public firms have methods for demonstrating a return ratio and not only cost savings. Therefore, choosing metrics and methodologies for calculating ROI is an important step in the decision-making process. This complexity complicates estimating a data centers' utility and the true value generation of merging data centers. This thesis will explore the challenges that the Marine Corps' faces for calculating ROI for data center consolidation.

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LIST OF ACRONYMS AND ABBREVIATIONS

BSC	Balanced Score Card
C4	Command, Control, Communications, and Computers
CAPEX	Capital Expense
CBA	Cost/Benefit Analysis
CBO	Congressional Budget Office
CCSD	Communications Circuit System Designator
CIO	Chief Information Officer
CO/CO	Contractor Owned/Contractor Operated
COE	Concept of Employment
COOP	Continuity of Operations
CoSC	Continuity of Service Contract
CPU	Central Processing Unit
CTP	Core Transition Plan
DAU	Defense Acquisition University
DBB	Defense Business Board
DCC	Data Center Consolidation
DCIM	Data Center Infrastructure Management
DHS	Department of Homeland Security
DISA	Defense Information Systems Agency
DISN	Defense Information System Network
DoD	Department of Defense
DON	Department of the Navy
DSE	Digital Service Efficiency
DTS	Department of Technology Services (State of Utah)
FCoE	Fibre Channel over Ethernet
FDCCI	Federal Data Center Consolidation Initiative
GAO	Government Accountability Office
GDA	Government Directed Actions
GIG	Global Information Grid
GO/GO	Government Owned/Government Operated

HBA	Host Bus Adapters
HDN	Homeland Defense Network
HQMC	Headquarters Marine Corps
IaaS	Infrastructure as a Service
IAVA	Information Assurance Vulnerability Alert
INMS	Integrated Network Management System
I/O	Input/Output
IP	Internet Protocol
IRR	Internal Rate of Return
ISACA	Information Systems Audit and Control Association
IT	Information Technology
ITIL	Information Technology Infrastructure Library
JCIDS	Joint Capabilities Integration and Development System
JIE	Joint Information Environment
LLC	Limited Liability Corporation
MAGTF	Marine Air Ground Task Force
MCEITS	Marine Corps Enterprise Information Technology Services
MCIE	Marine Corps Information Enterprise
MCEN	Marine Corps Enterprise Network
MCICOM	Marine Corps Installations Command
MCI-W	Marine Corps Installations-West
MCNOSC	Marine Corps Network Operations Support Center
MITSC	MAGTF Information Technology Support Center
MPLS	Multiprotocol Label Switching
NAVADMIN	Naval Administrative Message
NGEN	Next Generation Enterprise Network
NIPR	Non-classified Internet Protocol Router
NMCI	Navy-Marine Corps Intranet
NPV	Net Present Value
NIST	National Institute of Standards and Technology
NMS	Network Management System
OC	Optical Transmission

OMB	Office of Management and Budget
OPEX	Operating Expense
PaaS	Platform as a Service
PC	Personal Computer
P2V	Physical to Virtual
QoS	Quality of Service
RAM	Random Access Memory
ROA	Return on Assets
ROC	Return on Capabilities
ROI	Return on Investment
SaaS	Software as a Service
SAN	Storage Area Network
SE	Supporting Establishment
TCO	Total Cost of Ownership
UCP	Unification Campaign Plan
USA	United States Army
USDA	United States Department of Agriculture
USMC	United States Marine Corps
VDI	Virtual Desktop Infrastructure

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ACKNOWLEDGMENTS

I would like to thank my wife and children for all their support, patience, and love. My thankfulness and appreciation surpass expression.

I thank my fellow brothers and sisters at Seaside First Baptist Church for your prayers and support. To God be the glory.

I thank Lieutenant Colonel Scott Voigts for helping me develop the topic for this thesis. Our common desire to improve how the Marine Corps develops and invests in information technology was a key impetus for this research.

I would also like to thank Glenn Cook and Dr. Thomas Housel for their keen insights and mentorship in seeing this thesis come to fruition.

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I. INTRODUCTION

A. PURPOSE

The purpose of this research is to propose recommendations that managers and senior leaders can use to help appraise the efficiency and efficacy of their data centers and to explore the shortfalls and challenges in calculating the Return on Investment (ROI) for consolidation. Under the Federal Data Center Consolidation Initiative (FDCCI), many organizations are wrestling with the mandate to consolidate their data centers in order to reap the benefits consolidation may provide. Yet, consolidation is not a one-size-fits-all imperative. A comprehensive and measured response will need to be taken to ensure that consolidation is the right solution and ensure that any investments in Information Technology to support data center consolidation achieves a positive Return on Investment (ROI).

B. BACKGROUND

On 9 December 2010, former Federal Chief Information Officer (CIO), Vivek Kundra, issued the U.S. Government's 25-Point Implementation Plan to Reform Federal Information Technology Management. The first step in the plan's implementation requires government agencies to consolidate 40 percent of their 3,133 data centers by 2015 based off of the Federal Data Center Consolidation Initiative (FDCCI) issued in February 2010 (Federal Technology Insider, 2013). The FDCCI (2010) has four aims:

- Promote the use of Green IT by reducing the overall energy and real estate footprint of Government data centers
- Reduce the cost of data center hardware, software, and operations
- Increase the overall IT security posture of the government, and
- Shift IT investments to more efficient computing platforms and technologies.

These goals will require CIOs to assess the best way to allocate their information technology (IT) budgets. In a recent update to these efforts, the current Federal CIO, Steve VanRoekel (VanRoekel, 2013), testified before the U. S. House Committee on Oversight and Government reform and stated that:

> To maximize our investment, the Government must better manage the cost of providing IT services. Managing IT in an innovative way means consolidating redundant applications, systems, and services. It also means establishing common testing platforms to foster interoperability and portability so that we can build once and then use many times across the whole of Government. We must streamline the delivery of new infrastructure, and shift from asset ownership to service-orientation, which means that technology is delivered as a service - much like water or electricity - rather than built as a proprietary system. By culling from inefficiency and reinvesting in high ROI areas [emphasis mine], we can drive innovation in government that creates efficient, mission-focused technology solutions. (p. 2)

VanRoekel (2013) is not alone in requiring that government IT initiatives maximize benefits. The Office of Management and Budget (OMB) also requires a cost-benefit analysis as a key requirement of agencies' data center consolidation plans (GAO, 2012). Coupled with recent federal budget cuts under the Budget Control Act of 2011, CIOs are now faced with limited choices on where to invest their shrinking IT dollars. A memo issued by the Department of the Navy (DON) CIO, Terry Halvorsen, states that he "will need to work with all Secretariat organizations to determine a cost effective way ahead on data center consolidation and rationalization of systems/applications" (Halvorsen, 2013, p. 1). A recent projection by the Congressional Budget Office (CBO) also shows that the DoD's budget is projected to decrease for the foreseeable future (J. Szewc, personal communication, June 19, 2013)[1].

[1]). Study provided by John Szewc from Brocade. United States Marine Corps network infrastructure study: An analysis of the current networking environment in light of declining budgets and advances in networking technology. Performed by Cask, LLC.

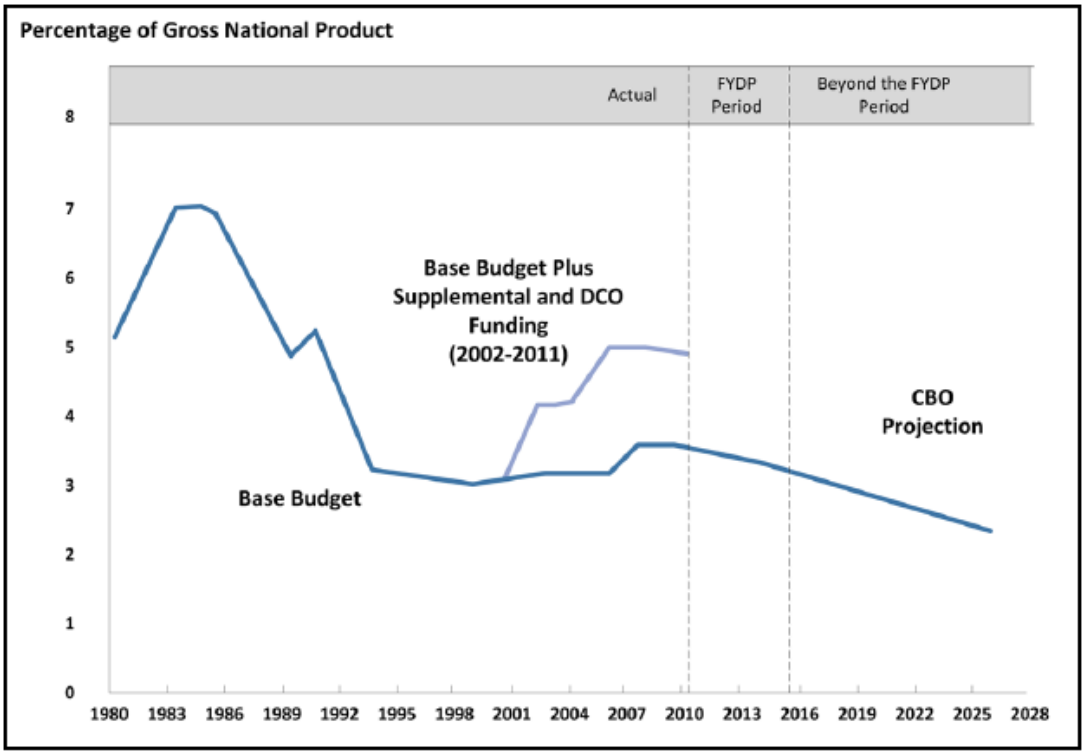

Figure 1. Decreasing DoD Budget
(From J. Szewc, personal communication, June 19, 2013)[2]

Federal policies mandate that investments in information technology (IT) demonstrate a positive return on investment (ROI). For example, The Clinger-Cohen Act (1996), the Government Accountability Office's (GAO) (1997) guide on Assessing Risks and Returns, and DoD Directive 8115.01 (2005) all mandate that IT investments are assessed using a cost-benefit analysis with such measurements as ROI. Furthermore, Marine Corps Information Enterprise (MCIE) Supporting Establishment (SE) Concept of Employment (COE) Strategy (2012, p. 63) mandates that decision makers "tasks assess the overall value of an IT service, the costs of underlying assets associated with its provisioning, and its impact on Marine Corps-wide operations." MCIE Strategy (2012, p. 63) directs Marine leaders responsible for IT projects to ensure cost-benefit value and projected Returns on Investment (ROIs) are calculated "before making a decision to

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move forward with establishing a new IT service capability to ensure that limited USMC IT resources are most effectively used."

It is a well-published fact that both public and private organizations have yielded considerable savings from consolidating data centers through rationalization, centralization, virtualization, and integration, see Figure 2. However, assessing the ROI for IT in the public sector faces some significant challenges.

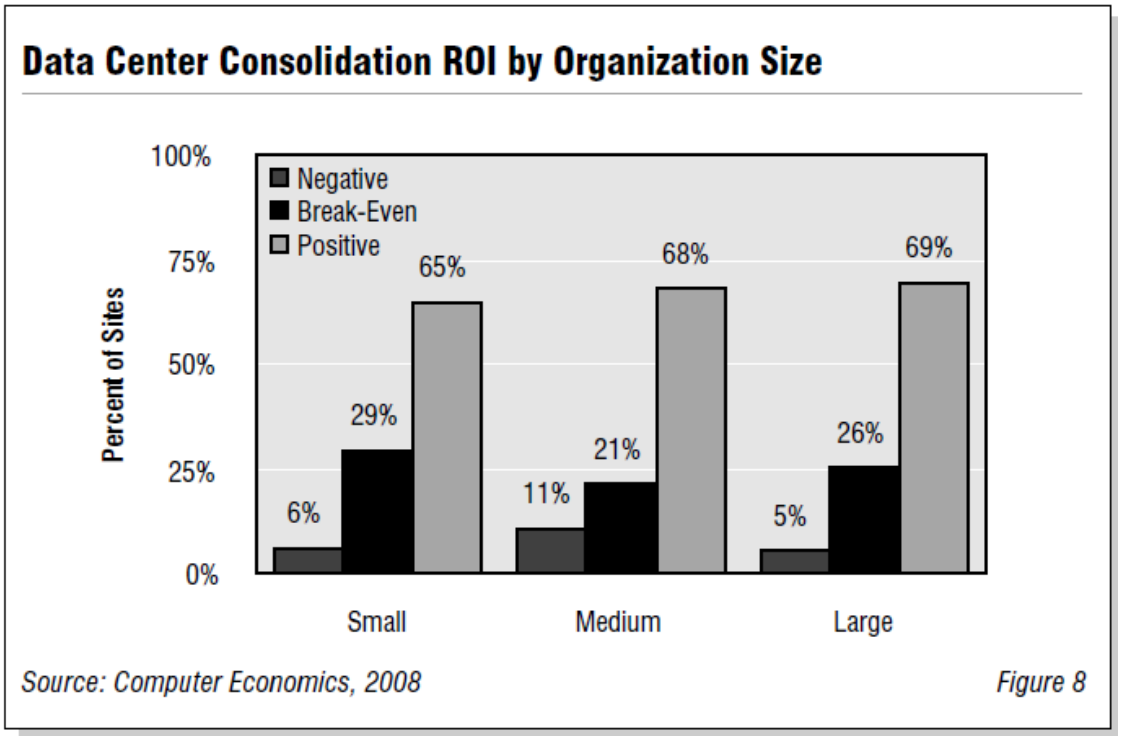

Figure 2. Making the Case for Data Center Consolidation
(From Computer Economics, 2008)

First, there are no standards for ROI calculation (Botchkarev & Andru, 2011). This makes it difficult to compare projects across industries in order to have defined benchmarks for comparison. In fact, Pavlou et al. (2005) demonstrate that there exists many different ways to calculate Return on IT in Table 1.

Table 1. Common Approaches for Measuring the Return on IT (After Pavlou et al., 2005)

Level of Analysis	Approach	Focus	Example	Key Assumptions	Key Advantage	Limitations
Aggregate Corporate (firm) level	Process of Elimination	Treats effect of IT on ROI as a residual after accounting for other capital investments	Knowledge capital (Strassmann, 2000a, b)	ROI difficult to measure	Uses commonly accepted financial analysis techniques and existing accounting data	Cannot drill down to effects of specific IT initiatives
	Production Theory	Determines the effects of IT through input output analysis using regression modeling techniques	Brynjolfsson & Hitt (1996)	Economic production function links IT investment input to productivity output	Uses econometric analysis on large data sets to show contributions of IT at firm level	"Black-box" approach with no intermediate mapping of IT's contribution to outputs

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Level of Analysis	Approach	Focus	Example	Key Assumptions	Key Advantage	Limitations
Aggregate Corporate (firm) level	Resource-Based View	Linking firm core capabilities with competitiveness	Jarvenpaa & Leider (1998)	Uniqueness of IT resource = competitive advantage	Strategic advantage approach to IT impacts	Casual mapping between IT investment and firm competitive advantage difficult to establish
Corporate/sub-corporate	Option Pricing Model	Determines the best point at which to exercise an option to invest in IT	Benaroch & Kauffman (1999)	Timing exercise option= value	Predicting the future value of an IT investment	No surrogate for revenue at sub-corporate level
Sub-corporate (Process)	Family of Measures	Measure multiple indicators to derive unique contributions of IT at sub-corporate level	Balanced score-card (Kaplan & Norton, 1996)	Need multiple indicators to measure performance	Captures complexity of corporate performance	No common unit of analysis/theoretical framework

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Level of Analysis	Approach	Focus	Example	Key Assumptions	Key Advantage	Limitations
Sub-corporate (Process)	Cost-Based	Use cost to determine value of information technology	Activity-based costing Johnson & Kaplan (1987)	Derivations of cost ≈ value	Captures accurate cost of IT	No surrogate for revenue at sub-corporate level – no ratio analysis
	Knowledge Value Added	Allocating revenue to IT in proportion to contributions to process outputs	Housel & Kanevksy (1995)	IT contributions to output ≈ IT value-added	Allocates revenue and cost of IT allowing ratio analysis of IT value-added	Does not apply directly to highly creative processes

Second, IT does not always produce tangible benefits such as revenue, which is a key input to the ROI equation. As a result, valuing intangible benefits such as improved customer satisfaction or enhanced company image can become subjective and difficult to monetize. Yet, ROI is one of the most popular financial metrics to use when comparing one information technology (IT) investment to another (Botchkarev & Andru, 2011). Botchkarev and Andru (2011, p. 1) also state, "ROI has been widely recognized and accepted in business and financial management in the private and public sectors. It is an important metric used by many Chief Information Officers to calculate the potential efficiency of investments in IT."

C. RESEARCH OBJECTIVES

The objective of this research is three-fold. First, the researcher will seek to distill the various forms of calculating ROI for organizations in the public sector. Second, the objective is to explore the seams and gaps in the current Marine Corps data center environment. Third, the researcher will use a case study of a large scale data center consolidation effort by the state of Utah to propose recommendations to Marine Corps Installations Command (MCICOM) data center consolidation efforts.

D. RESEARCH QUESTIONS

1. Primary Research Question

What are the challenges in assessing the Return on Investment (ROI) for DoD Data Center Consolidation efforts?

2. Secondary Research Question

Under the Next Generation Enterprise Network, what are the seams and gaps in the Marine Corps' ability to assess its information technology investments?

E. METHODOLOGY

The initial research will be based on scholarly articles that address data center cost metrics, ROI, and federal policies on IT investments that effect IT procurement. This thesis

looks to synthesize knowledge in assessing the ROI for data center consolidations by providing recommendations for valuing benefits and opportunity costs of these mergers.

Additionally, within the means available, the research will look to apply the recommendations that surface within the examination of the aforementioned studies to a real-world case involving the consolidation of data centers for Marine Corps Installations-West.

F. SCOPE

An examination of the long history of data center consolidation within the federal government at large and the challenges associated with public sector ROI. This research contributes to the field of IT by raising the awareness of the need to develop alternative measures of effectiveness outside of cost savings and cost avoidance alone. Furthermore, the research explores the seams, gaps, and strengths within the data center environment for assessing the ROI. Lastly, it compares data center consolidation efforts of similar organizations to identify shortfalls in people, processes, technology within the Marine Corps.

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II. LITERATURE REVIEW

A. OVERVIEW

This chapter begins with an in-depth literature review on issues in modern data centers writ large and federal mandates regarding investments in Information Technology (IT). An introduction to the history and impetus for Data Center Consolidation (DCC) within the United States federal government and some of the burgeoning obstacles it faces in the current fiscal environment are presented. The researcher also presents the various issues and methodologies in Return on Investment (ROI) literature for public sector firms and various models for valuing the contributions of IT. Last, market comparables is briefly discussed to address the challenges of valuing the benefits IT produces in public sector organizations.

B. BACKGROUND

The Federal Data Center Consolidation Initiative (FDCCI) mandates that federal agencies consolidate data centers to reduce overall operating costs and reduce energy consumption (FDCCI, 2010). Additionally, consolidation as cited by the FDCCI (2010), may save on real estate costs, optimize space, improve hardware utilization, and enhance security. However, a study by Juniper Networks (2011, p. 6) cited that Federal data centers are nearing capacity: "Yet by 2015, agencies will have nearly 40 percent fewer data centers to do nearly 40 percent more work." They also cite that data centers are more diverse than previously thought and consolidation will only increase complexity of the fewer data centers (Juniper, 2011). Modern data center traffic is also increasing data center complexity. Most data centers were designed for client server technology, which means the traffic patterns were predominantly "north-south," meaning that traffic was exiting and entering the data center (Juniper, 2012, p. 1). However, virtualization has fundamentally changed this traffic pattern to more "east-west," meaning the traffic moves more within the data center (Juniper, 2012, p. 1). As a result, virtualizing not only increases data center complexity, but may also require an investment in changing the fundamental architecture of the data center to fully leverage its capabilities and benefits (Juniper, 2012).

Accordingly, the Defense Business Board (DBB) (2012) noted in a recent review of consolidation efforts that data center consolidations will require a significant upfront cost. The 2012 Defense Authorization Act (reiterated in Navy Policy-NAVADMIN 165/12) for funding data centers requires that federal agencies consolidate data centers into existing ones and find native solutions without obligating additional funds for more IT. This is important because, as previously cited by the DBB; data center consolidation will require significant initial upfront costs that will need to be vetted through the proper channels for procurement; thus, slowing data center consolidation efforts even further and causing a conundrum for the IT managers responsible for these efforts.

Data center consolidation also has several meanings, and each can come with its own sets of benefits and problems. Spellman et al. (2003) point out that consolidation can be defined in many terms such as centralization, physical consolidation, and data and application integration. Their article highlights the need to perform consolidation in terms of "Stepwise Refinement," which ensures analysts model key performance parameters and business goals (Spellman, 2003, p. 31). Hence, consolidation in itself should not be the ultimate goal, rather improving business processes and performance should be the ultimate end state. Consolidation also entails an increased level of virtualization in order to accommodate the needs of the agencies and data center supports. In fact, 60 percent of data centers are running over 20 different operating systems and nearly 50 percent are running more than 20 different business applications (Juniper Networks, 2011). Therefore, complexity is further compounded when consolidation takes place. Security is another issue that arises with virtualization. Kaufman (2009) points out that vulnerability in server virtualization software could also propagate to other virtual servers very rapidly if they are all located on the same host. This has been a known problem in multi-tenant architectures for some time with no easy solutions. Wang and Eugene (2010) also found that even in small multi-tenant environments that virtualization caused significant throughput instability and irregular delays in network traffic.

Finally, the current progress of the FDCCI has also come under scrutiny. The Government Accountability Office (GAO) has published a yearly report since 2011 that has documented progress of the consolidation process. The GAO found that over a two-

year period only one out of twenty-four agencies have fully complied with FDCCI. Moreover, after two years most of the agencies are still in the beginning stages of data center consolidation. Worse, the majority do not even have their inventories completed. To help resolve this issue, the FDCCI has been added to the Office of Management and (OMB) PortfolioStat (Konkel, 2013). Tracking agency progress has been difficult to track and sporadic. By adding data center consolidation to PortfolioStat will allow the OMB to track the progress made by agencies by using what they call "evidence-based review" to ensure progress is being made (Konkel, 2013). Indeed, data center consolidation is proving extremely challenging for all federal organizations.

C. DEFINITION OF A DATA CENTER

The definition of what comprises a data center has gone through several revisions. According to the original FDCCI, the Office of Management and Budget (OMB) defined data centers as "rooms that meet certain size, purpose, and availability requirement[s]" GAO (2012, p. 5). Unfortunately, this previous definition did not capture the intent of OMB and did not capture the smaller data centers in its tallies (GAO, 2012). In October 2011 the Federal CIO announced that an expanded definition would include facilities of all sizes (GAO, 2012). The expanded definition follows:

> A data center is…a closet, room, floor or building for the storage, management, and dissemination of data and information and [used to house] computer systems and associated components, such as database, application, and storage systems and data stores [excluding facilities exclusively devoted to communications and network equipment (e.g., telephone exchanges and telecommunications rooms)]. A data center generally includes redundant or backup power supplies, redundant data communications connections, environmental controls…and special security devices housed in leased, owned, collocated, or stand-alone facilities (p. 5).

This expanded definition was also reiterated by United States Navy in NAVADMIN 165/12 (2012) in order to amplify SECNAV instructions that align with the expanded OMB definition. Under this new definition, the number of new data centers could easily expand.

D. RETURN ON INVESTMENT FOR IT

Making decisions on data center consolidation is not only technically difficult, but financially difficult. A recent poll conducted by the 1105 Government Information Group (2012) highlights this in a report that shows many IT professionals have a difficult time showing ROI for data center optimization; see Figure 3.

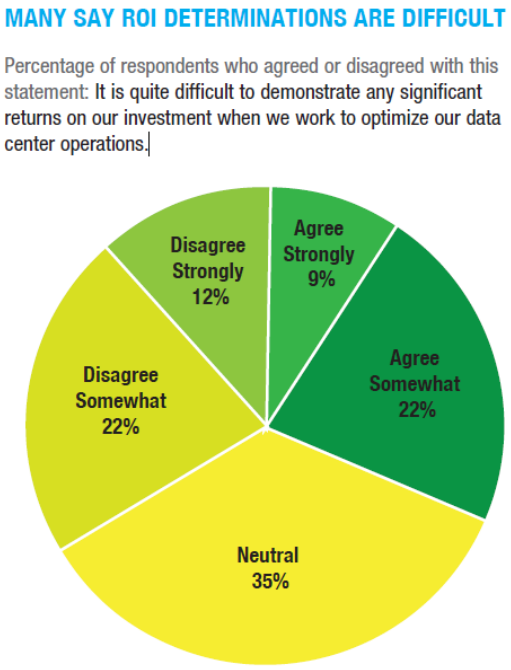


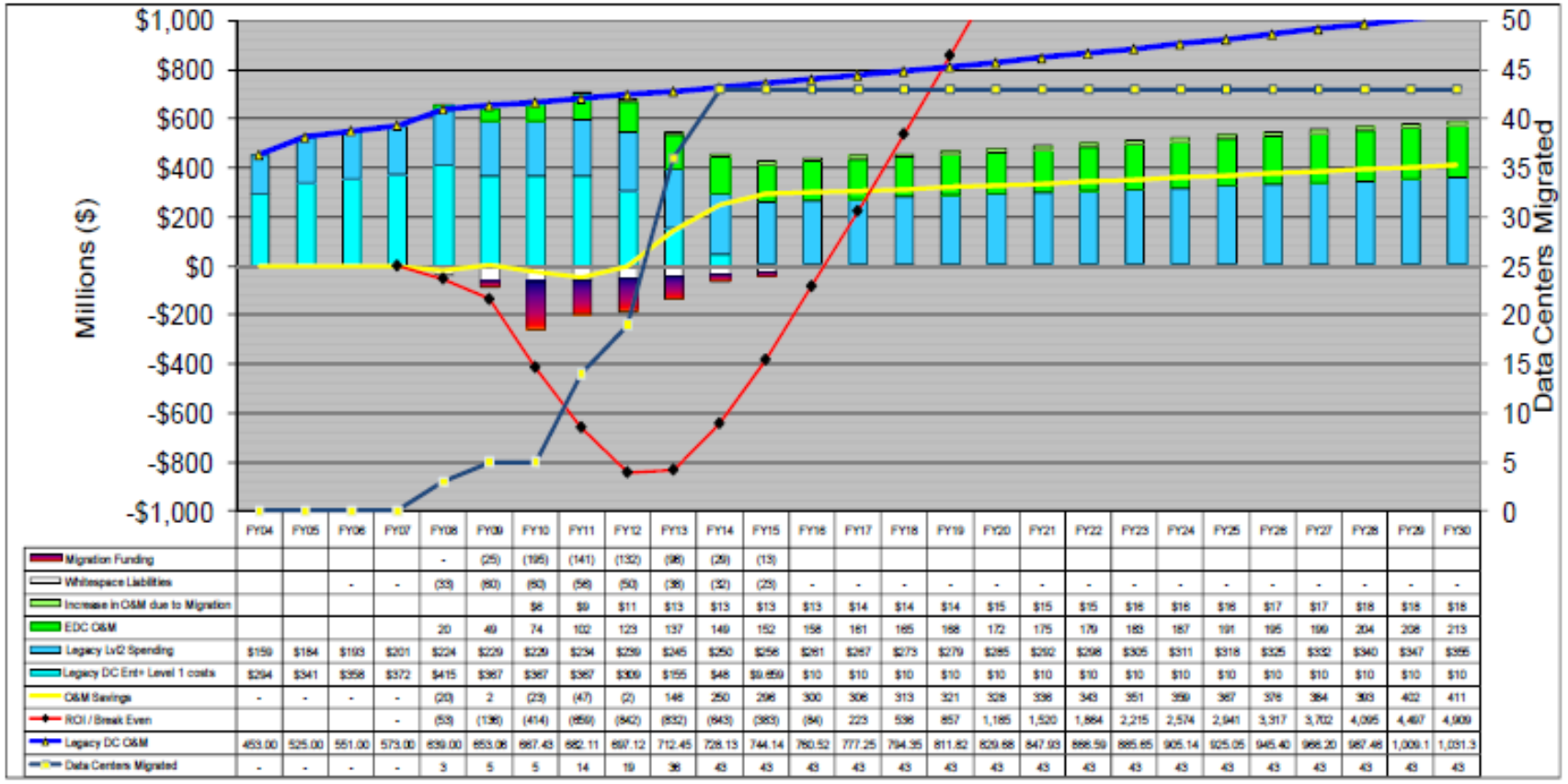
Figure 3. Data Center Optimization (From 1105 Government Information Group, 2012)

The Marine Corps Information Enterprise (MCIE) Supporting Establishment (SE) Concept of Employment (COE) Strategy (2012, p. 63) mandates that decision makers tasks' "assess the overall value of an IT service, the costs of underlying assets associated with its provisioning, and its impact on Marine Corps-wide operations." Furthermore, MCIE Strategy (2012, p. 63) directs Marine leaders responsible for IT projects to ensure cost-benefit value and projected Returns on Investment are calculated "before making a decision to move forward with establishing a new IT service capability to ensure that limited USMC IT resources are most effectively used." In today's fiscally constrained environment, this will prove challenging. For example, the Department of Homeland

Security's FDCCI Progress (2011) report demonstrates that their data center consolidation is currently projecting a negative ROI until 2017,; see Figure 4.

The other issue surrounding ROI in IT centers is how it is calculated. Michael Smith from the Gartner Group stated, "The issue isn't ROI as such, but defining metrics that are useful and meaningful" (Banham, 2005, p. 1). The revenue generating commercial sector uses a simple ROI calculation which is standard across most private sector firms. ROI is typically presented as a ratio or percentage and is calculated as follows:

ROI = ((Gains – Investment Costs) / Investment Costs) x 100%
Exampl*e*: (($600,000 – $500,000) / $500,000) x 100% = 20 % ROI



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
Migration Funding					-	(25)	(195)	(141)	(132)	(86)	(29)	(13)															
Whitespace Liabilities			-	-	(33)	(60)	(82)	(56)	(50)	(36)	(32)	(25)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Increase in O&M due to Migration							$6	$9	$11	$13	$13	$13	$13	$14	$14	$14	$15	$15	$15	$16	$16	$16	$17	$17	$18	$18	$18
EDC O&M					20	49	74	102	123	137	149	152	158	161	165	168	172	175	179	183	187	191	195	199	204	208	213
Legacy Lvl2 Spending	$159	$184	$193	$201	$224	$229	$229	$234	$259	$245	$250	$256	$261	$267	$273	$279	$285	$292	$298	$305	$311	$318	$325	$332	$340	$347	$355
Legacy DC Ent+ Level 1 costs	$294	$341	$358	$372	$415	$367	$367	$367	$309	$155	$48	$9.659	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10
O&M Savings	-	-	-	-	(20)	2	(23)	(47)	(2)	146	250	296	300	306	313	321	328	336	343	351	359	367	376	384	393	402	411
ROI / Break Even				-	(53)	(136)	(414)	(656)	(842)	(832)	(643)	(383)	(84)	223	536	857	1,185	1,520	1,864	2,215	2,574	2,941	3,317	3,702	4,095	4,497	4,909
Legacy DC O&M	453.00	525.00	551.00	573.00	639.00	653.06	667.43	682.11	697.12	712.45	728.13	744.14	760.52	777.25	794.35	811.82	829.68	847.93	866.59	885.65	905.14	925.05	945.40	966.20	987.46	1,009.1	1,031.3
Data Centers Migrated	-	-	-	-	3	5	5	14	19	36	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43

Figure 4. Department of Homeland Security (DHS) (From FDCCI Progress Report, October 2011)

Therefore, increasing ROI is a matter of decreasing cost, increasing benefits, or some combination of the two. Another way it is interpreted is as follows:

- zero (= 0%), equals breakeven point for the investment
- Greater than zero (> 0%), there is a direct cost benefit with the investment
- Less than zero (< 0%), there is a negative direct cost benefit with the investment

E. CHALLENGES IN USING ROI IN THE PUBLIC SECTOR

ROI is very common in the private sector to measure rate of return; however, the ROI equation poses a problem for the public sector and specifically for the military. Sciarretta et al. (2008, p. 7), aptly point out that the U.S. Army, for example, does not "make a profit, save money, nor increase market share." Furthermore, Sciarretta et al. (2008) point out that benefits accrued from science and technology in general are difficult to measure because most are intangible and must be assigned a value in order to calculate any meaningful ROI. Jacoby and Luqi (2005) echo the same concerns by stating that translating benefits of any IT system into financial equivalents is a problem that is well understood by business professionals. Nguyen (2004) further emphasizes that the ROI of IT is indispensable for bringing transparency and accountability e to public sector investments. In summary, Figure 5 summarizes some of the dominant problems with assessing the ROI for data center consolidation.

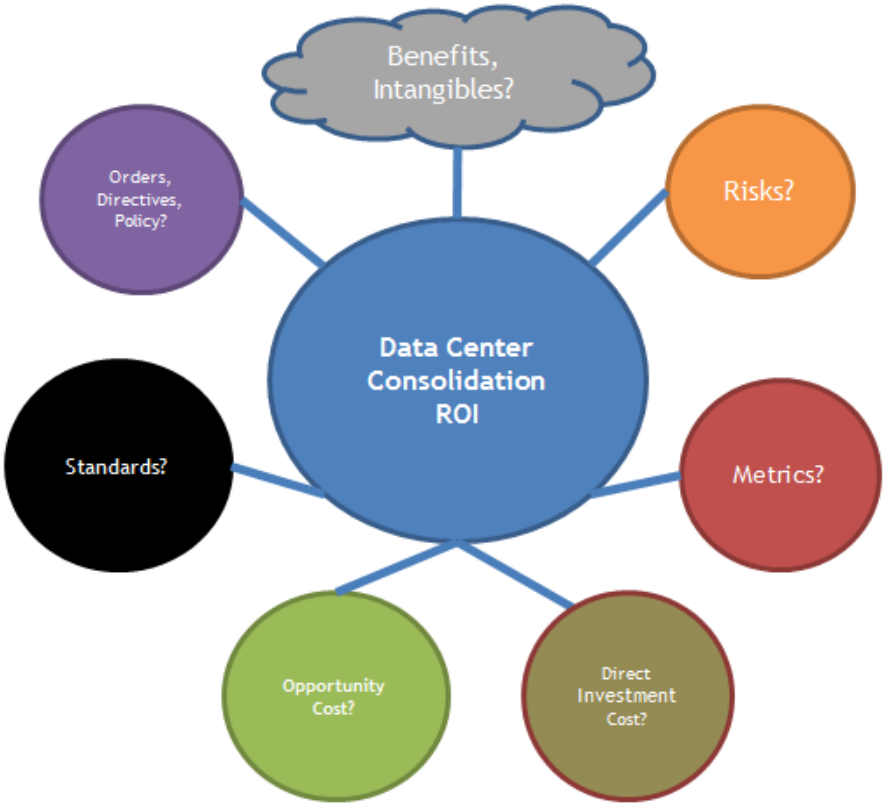


Figure 5. Summary of Problems Surrounding Data Center Consolidation.

F. ROI MODELS

1. Survey of Public Sector ROI Methods for Information Technology

Return on Investment (ROI) is one of the most popular performance measurements and evaluation metrics used in business analysis (Botchkarev & Andru, 2011). Its popularity is often due to its simplicity. The ROI calculation measures the efficiency of an investment. By measuring the return minus the cost of the investment divided by the cost of the investment, a decision maker can deduce if a capital expenditure makes fiscal sense. In fact, OMB Circular A-130 (2000, para. 8.b.(1).(b).(v)) states agencies must "demonstrate a projected return on investment that is clearly equal to or better than alternative uses of available public resources for Federal Information Resources." Yet, calculating ROI in the public sector provides some unique challenges.

There are different interpretations to what ROI actually entails. In its most strict form ROI is benefits divided by cost with the dividend given as a percentage (Federal CIO Counsel, 1999). A more commonly held belief is that ROI encompasses a great deal more. For instance, the Federal CIO Counsel (1999) also cites that both public and private sector organizations commonly group Net Present Value (NPV), Balanced Score Card (BSC), Discounted Payback Period, Cost/Benefit Analysis (CBA), and Internal Rate of Return (IRR) to mean ROI. Even though this provides IT managers a better overall picture of different aspects of an investment, it can provide more confusion than help. Cresswell (2004) states that because there is a divergence of opinions on which financial measurements are best, government executives have a difficult time deciding on what the best approach should be. This is problematic because if similar agencies have different ways of calculating ROI, it becomes difficult to compare the efficacy of their respective efforts. Furthermore, without a consistent methodology for measuring ROI, agencies can choose which approach demonstrates the best results, which could lead to incorrect investment decisions by IT managers.

Benefits or revenues for IT are often the most difficult to measure for several reasons. Most public sector IT does not produce revenue or anything tangible. Benefits for calculating the attractiveness of an investment are defined as an advantage, revenue, profit, or gain received (Federal CIO Counsel, 1999). These benefits help define an "investments return and should describe what the investment enables an agency to accomplish and how the mission is enhanced" (Federal CIO Counsel, 1999, p. 9). The benefits of IT are difficult to measure because they are often intangible or only mission enhancing which makes monetizing them difficult because of their subjective nature.

A typical substitute for revenues and profit in the public sector are cost savings and cost avoidance (Phillips, 2002). It is important to understand the differences between them; therefore, the following definitions are provided. Cost savings "are any actions that result in a smaller-than-projected level of costs to achieve a specific objective" (DAU, 2011a, para. 1). Put another way, cost savings are any reductions that enable a manager to apply the money saved to other uses (USA Cost Benefit Analysis Guide, 2011). Cost Avoidance is the "difference between two estimated cost patterns, one before the change and the one after" (DAU, 2011b). Under this methodology, cost savings and/or cost avoidance are provided as the numerator for the ROI equation; however, this poses

several problems that muddle only muddle the analysis. First, ROI is productivity ratio of two different dimensions. The inputs provide something different than the output. For example, a common productivity or efficiency ratio is miles per gallon, which measures how efficient a vehicle is for travelling on one gallon of fuel. As in Figure 6 given below by Housel (2010), 'A' is a different dimension than 'B' and they are not interchangeable. It would be illogical to conclude in a closed system, 'B' could yield 'B + n,' where n > 0; however, this is exactly what takes place when cost reductions or cost avoidance is placed in the numerator of the equation. Pavlou et al. (2005) also affirm that cost-based approaches lack a substitute for revenue. Therefore, a different measure of effectiveness or benefit needs to serve as the numerator.

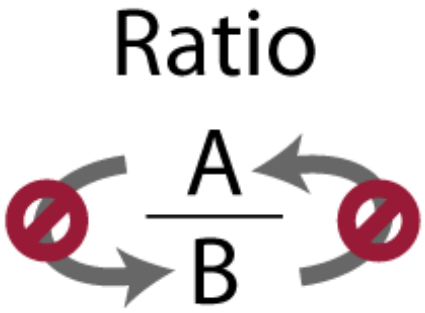


Figure 6. Measuring to Manage Knowledge
(From T. Housel, personal communication, March 15, 2013)[3]

Similarly, cost reductions and cost avoidance serve to reduce the denominator; however, this still requires qualification. The cost avoidance/cost savings from an investment cannot reduce the current denominator of the ROI equation that it serves to analyze. This would be wrong for several reasons. First, cost avoidance and cost reductions are functions of the investment and why the investment may be pursued; therefore, they are future, not current. Second, costs can be driven to zero by divesting or retiring the current technology and making no investment; however, benefits or outputs

[3] PowerPoint presentation provided by Dr. Thomas Housel from the Measuring to Manage Knowledge Conference given at the 3d Annual Knowledge Management for Learning Organizations 2010.

would also diminish. It is therefore fallacious to continually drive down costs, which results in a greater and greater ROI. This approach is made clear by Figure 7 below that demonstrates cost savings and performance are often contrary goals. Indeed, this approach is unsustainable and will eventually reach a point of diminishing returns in output for the organization. In reality, any firm that produces some form of output tangible or intangible cannot operate at zero cost. Therefore, benefits and costs need to be calculated independently of each other to ensure results can truly be measured accurately.

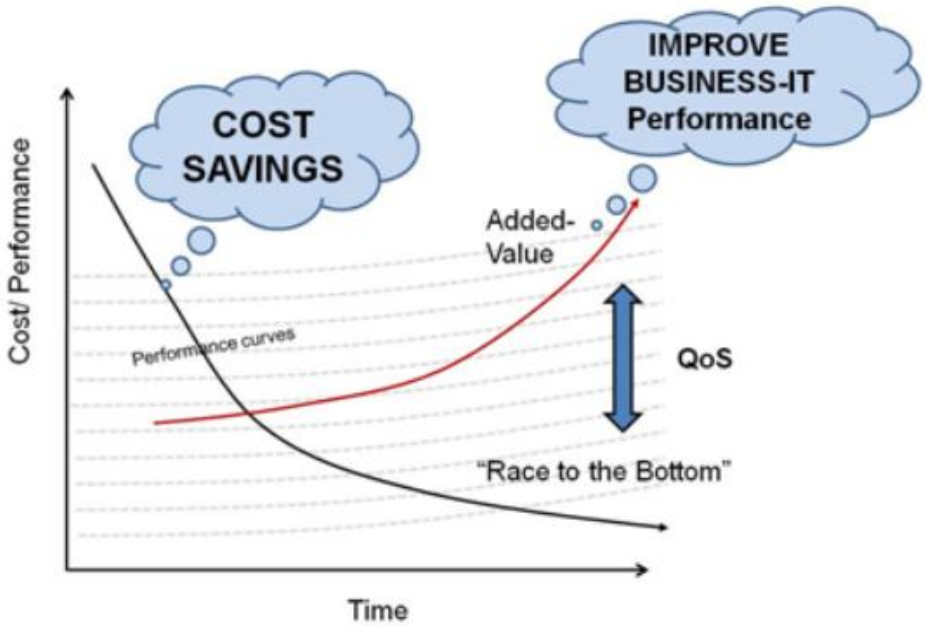


Figure 7. Cost Savings versus Goals (From The Open Group, 2013)

Last, ROI, NPV, IRR, BSC, Payback period, and CBA are not the only methodologies developed to calculate the effectiveness of IT investments. Because of the distinctive role many public sector services fulfill, developing a one-size-fits-all model may be impractical. Also, public sector firms often have different value propositions for their e-government service that make quantifying benefits challenging. For these reasons, Prakash, Jaiswal and Gulla (2001) demonstrated that many different valuation models exist for public sector organizations. For further information, see Table 2.

Table 2. Measurement of public value of enterprise applications in government and public sector (After Prakash, Jaiswal, & Gulla, 2001).

Name	Acronym	Year	Source
Social Return on Investment Model	SROI	1996	Roberts Enterprise Development Fund
Balanced E-Government Index	BEGIX	2001–02	Bertelsmann Foundation and Booz, Allen and Hamilton
Value Measure Methodology	VMM	2001–03	U.S. Social Security Administration and the General Service Administration
Public Service Value Model	PSV	2003	Accenture in cooperation with Kennedy School of Government, Harvard University
Performance Reference Model	PRM	2003	U.S. Federal Enterprise Architecture Program Management Office
Interchange of Data between Administrations Value of Investment	IDA VOI	2003	European Commission, DG Enterprise
Demand and Value Assessment Methodology	DAM & VAM	2004	Australian Government Information Management Office
Public Value Framework	PVF	2006	Center for Technology in Government, University at Albany, SUNY and supported by SAP
Performance Measurement of the Government On-line Initiative	PMAF	2004	Treasury Board of Canada Secretariat, developed for GOL Initiative
Logic Model for Government On-line Initiative	-	2004–05	GOL Initiative, Government of Canada
Public Value of IT	PVIT	2003–04	Andrea Di Mario, Research Vice President at Gartner
Public Value of IT-Enhanced	PVIT - Enhanced	2007	The World Bank
“Methode d’analsye et de remontee de la valeur” (The method for value analysis and increase)	MAREVA	2003–04	Developed by BearingPoint for the Agency for the Development of Electronic Administration (ADAE, France

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Name	Acronym	Year	Source
e-Government Economics Project	eGEP	2005	The European Commission (EC)
E-Governance Assessment Framework	EAF Version 2.0	2004	Department of IT, India with support from NISG and IIM, Ahmedabad
Impact Assessment Model	-	2005	Developed by NISG, ISG E-Gov, IIMA, LSE supported by the World Bank under JERP
Cyclic Assessment Framework Model	-	2007	Piyush Gupta, NISG, India
Return on E-Government and E-Government Performance Index	-	2004	Gupta and Jana

2. Market Comparables

One persistent problem that has existed for public sector organizations is valuing the benefits or outputs of their information technology. As previously mentioned, public sector does not exist to make a profit and as a result, making investment decisions based on ROI becomes problematic. Housel and Cook (2005) cite that this phenomenon is not new. In fact, this problem revolves around the paradox between information technology and productivity (Brynjolfsson, 1994). Organizations have spent considerable sums of money on information technology, but have a difficult time showing just how much it contributes to revenue generating activities, especially in the public sector. One way to overcome this disparity is to use a market comparable. A market comparable takes a similar private sector process and applies its revenue stream for that activity as a surrogate for potential revenue generated by a public sector organization (Housel et al., 2009, p. 16). Proxy revenue allows for a straight forward calculation of ROI for a public sector firm. As a result, the use of a market comparable can be used to estimate the revenue of a data center, and more importantly, estimate a potential ROI.

G. SUMMARY

In this chapter, the background of ROI as a means to evaluate investments across public and private sector firms was outlined. The use of ROI was shown to be a popular metric for assessing the efficiency of an investment. Nevertheless, choosing a ROI methodology that best fits the purpose and scope of a data center can be challenging and may not capture all the benefits an organization receives with investments in IT. Without an adequate way to measure output in a public sector company, alternative ways to measure potential benefits need to be addressed and assessed. Finally, the use of market comparables as a surrogate for revenues was also given to demonstrate that it provides an adequate means for estimating the numerator in the ROI equation.

III. MARINE CORPS INSTALLATIONS COMMAND (MCICOM) INFORMATION ENVIRONMENT

A. OVERVIEW

The challenges the Marine Corps faces with data center consolidation while transitioning to the Next Generation Enterprise Network (NGEN) are presented in this chapter. Recent reports also highlight the lack of consistent metrics and how elusive data center consolidation (DCC) cost-savings has been for the Federal agencies. Lastly, the researcher explores the shortfalls and challenges in the current Marine Corps information environment and a survey of the current MCI-W data center environment that as a sample.

B. BACKGROUND

Recent findings by the Government Accountability Office (GAO) (2013) stated that Federal agencies were behind on closing 258 data centers and have not determined if cost savings are achievable by 2015. Worse, recent testimony by the GAO's David Powner before a Congressional hearing stated that, collectively among different agencies, an additional 3,000 data centers have been found to exist—three years into this five year program (Johnson, 2013). Once again, the driving factor in many consolidation efforts are cost savings and cost avoidance; however, as stated by the GAO (2013, p. 2), a lack of "consistent and repeatable method for tracking cost savings" has not yet materialized as expected. Coupled with the fact many agencies have not discovered all the data centers they operate makes it difficult to baseline what it currently costs to operate them. These facts make the prospect of assessing the Return on Investment (ROI) extremely difficult.

Further complicating data center consolidation, is the Marine Corps' transition from Navy Marine Corps Intranet (NMCI) to NGEN. This is significant because NMCI is the second largest network in the world behind the Internet itself (J. Szewc, personal communication, June 19, 2013).[4] The NGEN will allow the Marine Corps to backsource its network from Contractor Owned/Contractor Operated (CO/CO) to a Government Owned/Government Operated (GO/GO) model. This shift will allow the Marine Corps to

[4] Study provided by John Szewc from Brocade. United States Marine Corps network infrastructure study: An analysis of the current networking environment in light of declining budgets and advances in networking technology. Performed by Cask, LLC.

exercise greater control over its Information Technology (IT) as it becomes increasingly important across all warfighting functions. The Marine Corps NGEN Program Core Transition Plan (CTP) (HQMC, 2012) cited several lessons learned over the last ten years under the Navy-Marine Corps Intranet (NMCI) that were problematic:

- The NMCI vendor could reject direction issued via Government Directed Actions (GDAs) as out of the scope of the contract regardless of the action's criticality or time sensitivity, which could have resulted in delaying or preventing execution of certain activities.
- The service provider had not been able to provide sufficient visibility and situational awareness of NMCI infrastructure and network defense related systems. Near real time network status provided by the vendor did not reflect major outages and lacked sufficient information to enable the DoN to assess operational impact.
- The vendor rarely communicated the root cause for major outages, which reduced the capability of the government to ensure that appropriate response actions were taken to avoid or prevent recurrences.
- The vendor still does not retain or provide adequate log data from critical systems, despite direction to do so by the government, thereby affecting the government's ability to investigate and properly respond to IA incidents.
- Slow technology refresh and upgrade of network infrastructure precluded agility in responding to emerging threats, much less the establishment of a proactive posture to try to stay ahead of the threat (p. 11-12).

One challenge to calculating ROI for data center consolidation is rooted in bullet two from the aforementioned NMCI lessons learned. Stated again, the "service provider had not been able to provide sufficient visibility and situational awareness of NMCI infrastructure" (HQMC, 2012, p. 12). This is problematic for several reasons. First, it is difficult to baseline costs and benefits in order to ensure future investments in IT meet or exceed current benefits. Second, without sufficient tools in place to discover assets that fit the Office of Management and Budget's (OMB) definition of a data center, the Marine Corps Installations West and its Marine Air Ground Task Force (MAGTF) Information Technology Support Center (MITSC) will have a difficult time assessing how IT impacts costs and how it contributes to their assigned mission.

NGEN will also decompose the former NMCI controlled network. It divides this former enterprise network into specific regions to support bases, posts, and stations across the globe, see Figure 8.

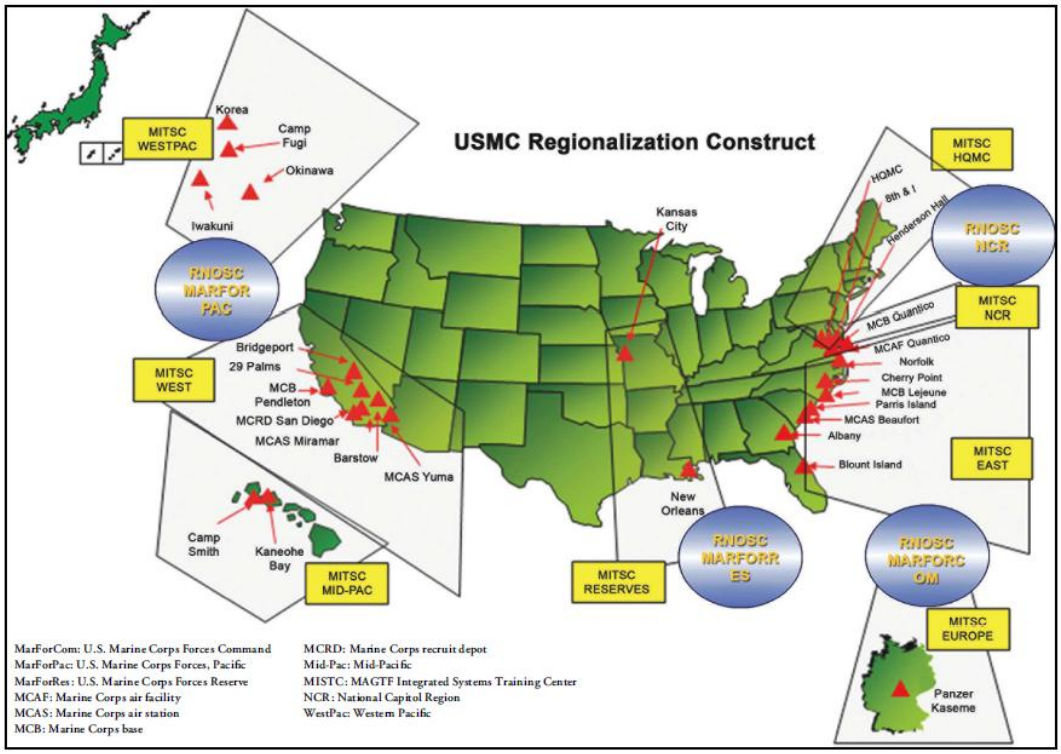

Figure 8. USMC Regionalization Construct (From Nally, 2013)

Each region is supported by a Marine Air Ground Task Force (MAGTF) Information Technology Support Center (MITSC) that will be the data and network operations center under the control of the individual Marine Corps Installation Commands (MCICs) (HQMC, 2012). The MITSCs will also be supported by the Marine Corps Network Operations Support Center (MCNOSC), which supports enterprise-level data center operations (HQMC, 2012). Figure 9 shows that the future vision of Marine Corps Enterprise Network (MCEN) is composed of many different architectures, applications, and sub-networks, which cut across several different lines of operation. This stresses the importance of coordination amongst the many different agencies within MCICOM and HQMC Command, Control, Communications, and Computers (C4).

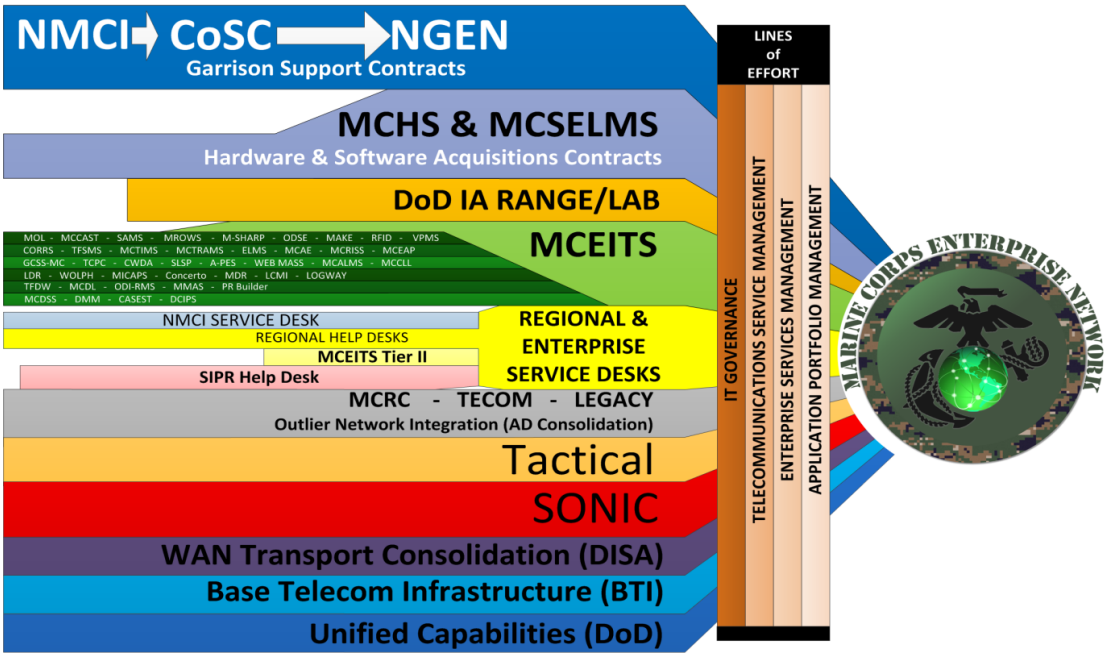

Figure 9. Future Vision of the Garrison Network (From Marine Corps Enterprise Network Unification Campaign Plan (MCEN/UCP) Brief to Executive Steering Group, 2013)

C. MARINE CORPS INSTALLATIONS INFORMATION ENVIRONMENT

With the transition to a government owned and partially government operated network on 1 June 2013, MCICOM faces many challenges with understanding the information environment. Without a clear understanding of this environment, calculating ROI will continue to remain elusive, especially in terms of assessing true costs. Cask, Limited Liability Corporation (LLC) (J. Szewc, personal communication, June 19, 2013)[5] performed a study on the current information environment and found the following weaknesses in the current Marine Corps network that increase costs, complexity and risk:

- Excessive Network Complexity: the current network is characterized by a diverse set of traffic flows and data streams that make it expensive, as well as inefficient to manually operate.

[5] Study provided by John Szewc from Brocade. United States Marine Corps network infrastructure study: An analysis of the current networking environment in light of declining budgets and advances in networking technology. Performed by Cask, LLC.

- Lack of Open Standard Protocols: the Marine Corps network is dominated by single-vendor infrastructure with Cisco equipment. Proprietary protocols create vendor lock-in and increases operating costs.
- Too Many Operating System Versions: organizations utilizing Cisco equipment have to track, manage, and maintain over 100 different versions of Cisco's Internetwork Operating System (IOS) running on devices on the network. This extreme level of IOS complexity places an excessively large burden on support staff and increases operations and maintenance costs.
- Classical Three-tier Network Model: the current network model relies on 2000-era architectures that are no longer viable in today's information environment that will be required to scale quickly and efficiently; therefore, significantly increasing the cost of operating the current architecture.
- Inadequate Network Management and Performance Monitoring: the lack of sufficient network management tools requires a greater degree of touch-labor to manually manage the network, which will greatly increase operating and maintenance costs. Furthermore, a lack of end-to-end monitoring in the Cisco environment compounds the issue. In fact, Cisco has no unified network management solution for data, storage, host bus adapters (HBAs), application delivery, wireless, and converged networks. To support Fibre Channel storage area networks (SAN), Fibre Channel over Ethernet (FCoE), Ethernet fabrics, IP switching, routing, wireless networks, and Multiprotocol Label Switching (MPLS) networks providing end-to-end network visibility across different network types requires multiple applications.
- Lack of Automation: The 2000-era practices of box by box configuration, direct command line interfaces, handcrafted configurations, separate teams, tools, and processes for network, security, servers, and applications, etc., are all outdated practices that are no longer practical for modern enterprise network operations. The lack of comprehensive policy based management, automated workflow, and dynamic virtual machine creation, etc., are outdated approaches that are now obsolete thanks to the latest advances in networking technology.
- Energy Efficiency: energy efficiencies translate into greater combat effectiveness for deployed forces and reduced costs for bases, posts, and stations.
- Empower Marines: The Marine Corps workforce must perform in an increasingly complex, dynamic, and highly integrated team-driven environment. Relying on a relatively small pool of specialists that are highly trained on proprietary protocols results in a smaller base of Marines empowered to support Marine Corps IT environments. (p. 9-16)

D. MCI-W INFORMATION ENVIRONMENT

MCI-W supports the entire western United States and is composed of the following bases and stations:

- Marine Corps Base Camp Pendleton, California
- Marine Corps Air Station Camp Pendleton, California
- Marine Corps Logistics Base Barstow, California
- Marine Corps Air Station Yuma, Arizona
- Marine Corps Air Ground Combat Center Twentynine Palms, California
- Marine Corps Air Station Miramar, California
- Marine Corps Recruit Depot San Diego, California
- Marine Corps Mountain Warfare Training Center Bridgeport, California

These eight bases and stations are also composed of many other support organizations and tenant commands that rely upon the base network infrastructure to support ancillary base operations and training. MCI-W supports approximately 55,000 Non-classified Internet Protocol (IP) Router (NIPR) users (S. Voigts, personal communication, 18 July, 2013). Its support staff consists of about 290 personnel that support all aspects of network operations. Approximately 20 to 30 are dedicated to supporting data centers proper (S. Voigts, personal communication, 20 August, 2013).

MCI-W provided a roll-up of known servers and applications that was performed in October 2012. Table 3 shows that there are at least four data centers on Camp Pendleton alone and a significant number spread across many other units under the MCI-W domain. Furthermore the roll-up identified 327 unique applications running within this environment. Lastly, this inventory also reported that NMCI employed 23 different 3rd party software tools to manage the network.[6]

[6] This does not include Hewlett-Packard's own proprietary network monitoring tools.

Table 3. List of servers across the MCI-W domain

Building Number	Number of servers
Building 1164 – Camp Pendleton	497
Building 2456 – Camp Pendleton	60
Building 2459 – Camp Pendleton	9
Building 1160 – Camp Pendleton	41
CLIN 27[7] (Various bases and stations)	408
Total	1,015 Servers

On 7 August 2012 FedTech (2012) interviewed Marine Corps Chief Information Officer (CIO) Brigadier General Kevin Nally. When asked about the status of the Marine Corps' efforts in fulfilling the mandates of the Federal Data Center Consolidation Initiative he stated, "We [the Marine Corps] are done." General Nally went on to say that:

> We went from 33 to 11 data centers. Those 11 include our MCNOSC, our Marine Corps Network Operations and Security Center in Quantico, Virginia. It also includes the MCEITS *[Marine Corps Enterprise Information Technology Services]* and a data center in Albany, Georgia, which is where logistics IT is located and which will eventually be a COOP *[Continuity of Operations]* site for MCEITS. We have 8 MITSCs or MAGTF IT Support Centers located throughout United States and in Europe (para. 40).

The gap between what was stated in the Brigadier General Nally interview and the list of data centers compiled afterward may be attributed to the NMCI lessons learned, which stated that the vendor did not provide adequate visibility of network resources and was incomplete (HQMC, 2012). Now that the Marine Corps has backsourced its network, data centers it did not officially own before 1 June 2013 have been inherited and need to be figured into the total data center count. Second, while Office of Management and Budget's (OMB) definition of a data center was updated in 2011, the exact interpretation may have conflicted with various institutional definitions of what constitutes a data center, thus confounding the issue further. Understandably, the MCEN UCP published 18 June 2013, states that the Marine Corps will continue to consolidate data centers (MCEN, 2013). With the discovery of additional assets that fit within OMB definition of a data center, opportunities abound to create even greater

[7] Contract Line Item Number (CLIN) 27 are connections to NMCI servers to support specific applications. These servers are located across the MCI-W domain and may represent a collection of additional data centers.

efficiencies with more consolidation of underutilized resources. Whether it is a single closet or an entire building, these resources need to be evaluated to understand if benefits from being managed within shared services infrastructure can yield better results.

Through personal communications with MCI-W, the researcher was able to obtain a snapshot of network utilization (S. Voigts, personal communication, 15 July 2013). Table 4 lists the main circuits that provide connectivity to other bases and stations and a Communications Circuit System Designator (CCSD). Associated monthly costs for each circuit were limited to the Homeland Defense Network (HDN) circuits. If a one month snapshot of utilization is indicative of circuit utilization, the Marine Corps could benefit by restructuring its network patterns through more efficient traffic management and perhaps reducing or replacing some transmission lines that could reduce costs. Indeed, this issue is being addressed presently by HQMC C4 in order to optimize the network (S. Voigts, personal communication, 15 July 2013). Nevertheless, the costs are significant for the capacity versus the utilization the HDN circuits provide and a more thorough analysis of network patterns and behaviors would need to be conducted.

Table 4. Table 4 Network Utilization and Cost Summary

Base	CCSD	End Point	Speed Mbs	Peak Bandwidth	Average Bandwidth	Cost
MCRD, San Diego	75NX	Miramar	45	100%	55.23	No Data Available
	7WZS	Miramar	45	100	<1%	No Data Available
	HDN (2523)	Cloud	155	<1%	< 1%	$56,364.00
	7M02	Beale AFB	45	12%	6%	No Data Available
Bridgeport, CA	75MR	Monterey	1.54	Data Pending	Data Pending	No Data Available
29 Palms, CA	73HZ	North Is.	9	87.34%	40.61%	No Data Available
	796L	Miramar	155	65%	30%	No Data Available
	HDN (4373)	Cloud	45	8.63%	9.07%	$106,992.00

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Base	CCSD	End Point	Speed Mbs	Peak Bandwidth	Average Bandwidth	Cost
Miramar, CA	72M3	North Is.	1.54	<1%	<1%	No Data Available
	70SY	Davis-Montham	1.54	<1%	<1%	No Data Available
	7XRY	Miramar	622	80.98%	17.29%	No Data Available
	701D	Miramar	1000	<1%	<1%	No Data Available
	HDN (9623)	Cloud	622	2.23%	<1%	$224,763.00
Camp Pendleton, CA	7VVX (Primary)	Beale	1000	57.45	52.67	$78,455.95
	7X1Z (Secondary)	Miramar	1000	1.22	<1	$62,357.60
	72NU	Davis	12	100+	100+	$3,606.34
	7NW1	LA AFB	1.544	0	0	$315.62
	HDN	Cloud	148	6.03	4.78	$224,916.00
Barstow, CA	7FFL	Miramar	45	50.47	23.24	No Data Available
	72MV	Edwards AFB	1.54	> 1	> 1	No Data Available
	HDN	Cloud	622	5.7	7.24	$345,840.00
Yuma, CA	72M1	Huachuca	1.544	<1	< 1	No Data Available
	7XNP	Miramar	155	43.55	21.84	No Data Available
	73V0	Miramar	1.544	< 1	< 1	No Data Available
	HDN	Cloud	155	6.87	4.75	$110,786.00

E. CHALLENGES AND OPPORTUNITIES AT MCI-W

From a network operations standpoint, there are many challenges to assessing and managing the current network, let alone performing a data center consolidation. The transition to a GO/GO environment has both potential and pitfall. Most importantly, the issue of discovery and managing network operations capacity are two of the main issues that will hinder data center consolidation and realizing ROI. This results in the inability to baseline current costs in order to assess if investments will provide improvements to current capabilities in cost and performance.

The NGEN transition is a significant undertaking. Backsourcing information technology requires a host of new skill sets, tools, and management practices that may not have existed before. For example, developing an Information Technology Infrastructure Library (ITIL) that meets current requirements and fills the gaps from the previous NMCI outsourcing arrangement are important and take time. ITIL is also important for data center consolidation and maintaining consistency across the enterprise domain. "ITIL makes the processes that govern data center operations documentable, auditable, and repeatable" (Babcock, 2007, para. 5). Additionally, redesigning the Microsoft Active Directory structure from an enterprise to a regional level will require time and effort. For these reasons, developing an ITIL and a new Active Directory structure for the region alone will be important to ensure compliance and interoperability across the many domains.

The proliferation of stand-alone servers and independent data centers or repositories also raises concerns over security. The current environment provides a larger surface area for nefarious activity or attack. This also makes it difficult to assess if every data center or repository abides by the same security standards, compliance with all Information Assurance Vulnerability Alerts (IAVAs), patches, configurations, and updates. It also raises questions of whether the personnel responsible for maintaining these untracked data centers have the requisite knowledge, clearances, expertise, and certifications required to operate them. Additionally, disparate data centers may not be covered under a comprehensive disaster recovery plan. In the end, a multiplicity of independent data centers can be too cumbersome to manage and secure effectively.

F. SUMMARY

The NGEN environment holds a great deal of opportunities for all stakeholders who use it. Armed with many lessons learned from the NMCI experience, the Marine Corps will need to set the conditions for success by adopting more modern network practices that will capture the Total Cost of Ownership (TCO) as well as benefits for its large number of data centers. Indeed, the Marine Corps' faces many significant challenges with its current information environment that will require large investments in resources and manpower to overcome these obstacles. More specifically, the MCI-W information environment is marked by a significant number of data centers that support over 300 applications operating under the same shortfalls that plague the current Marine Corps information environment writ large. In light of recent reports that most Federal agencies are having trouble showing actual cost savings, the Marine Corps will not be immune from the same scrutiny when their data centers are consolidated and networks are optimized. For these reasons, the Marine Corps will need to incorporate best practices found through similar successful data center consolidation efforts, which directly supports a robust information environment.

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IV. UNDERSTANDING AND ASSESSING THE VALUE OF A DATA CENTER

A. OVERVIEW

Valuing a data center is a very complex task because it can serve a variety of stakeholders. This chapter presents the stakeholder-based value model (SBVM) as a way to consider how benefits can be interpreted from data center consolidation. Next, lists of measureable data center metrics are presented that capture the mix of the most important data center characteristics and behaviors that drive cost and complexity. Last, a synthesis of lessons learned and best business practices from successful data center consolidation efforts are presented in order to identify current shortfalls in the Marine Corps' ability to assess return on investment (ROI) for data center consolidation.

B. STAKEHOLDER-BASED VALUE MODEL

Data centers serve a variety of customers that can derive value from IT in different ways. The value a data center delivers to customers can also change over time as processes are reengineered to leverage information technology (IT) to a greater level. For these reasons, calculating the benefits a data center delivers can be an insurmountable problem. Linking investments in data center consolidation and its direct benefits has been problematic for federal agencies for many reasons, which surround IT in general.

Jurison (1996) states that the three typical issues in assessing IT benefits are inappropriate measures, inappropriate unit of analysis, and failure to account for time lag. For instance, IT provides value in many ways that cannot be captured by traditional measures such as return on assets (ROA) because it is difficult to put a cost on customer satisfaction, increased system response time, or better QoS, otherwise known as "non-traditional sources of value" (Jurison, 1996, p. 264). The value of IT is also subjective. The same database application may be valued differently by similar organizations; however, if the value is aggregated at the firm macro level, lower value returns on IT can be offset by higher returns in another part of the organization, which makes identifying the low performers difficult (Jurison, 1996). This is especially true in data centers

because they often host many diverse applications for an even more diverse set of customers. Investments in IT often suffer from benefits that characteristically have a time lag (Jurison, 1996). Investment costs are typically immediate, while benefits may take up to ten years to yield measurable results (Jurison, 1996). In more recent research, Tambe and Hitt (2012) also found that the larger the organization, the greater time it can take for it to completely realize benefits. This is especially true for merging data centers because most data centers require an initial upfront investment in virtualization software and more efficient hardware to accommodate increased workloads on servers in preparation for consolidation. For these reasons, decision makers for IT need to open their apertures beyond cost savings and cost avoidance. The benefits of IT are multidimensional in many respects and cannot be calculated by a single metric (Jurison, 1996). Therefore, any investment in IT is best evaluated as a portfolio that captures the benefits of all stakeholders. Figure 10 depicts the different cost and benefit flows found in IT. It demonstrates that firms receive both direct and indirect benefits from investments in IT from many different stakeholders. The direct benefits are often the easiest to measure such as increased revenues. The indirect benefits are more difficult to measure because they can vary widely from stakeholder to stakeholder.

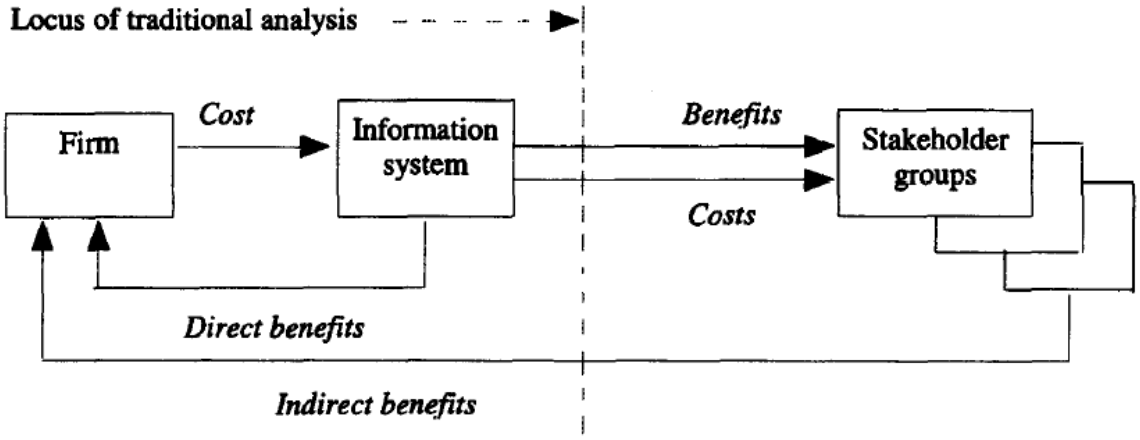

Figure 10. Information Technology cost and benefits flow (From Jurison, 1996)

The SBVM is shown in Figure 11. It demonstrates that the categories of 'cost' and 'value' span from firm to employee to customer. In other words, each entity has a

cost to bear and will receive some form of value that should ideally outweigh the cost. Simply put, if the value of the product or service is greater than the cost, then the entity has a positive net gain. As a result, the firm receives benefits in the form of revenues and higher productivity.

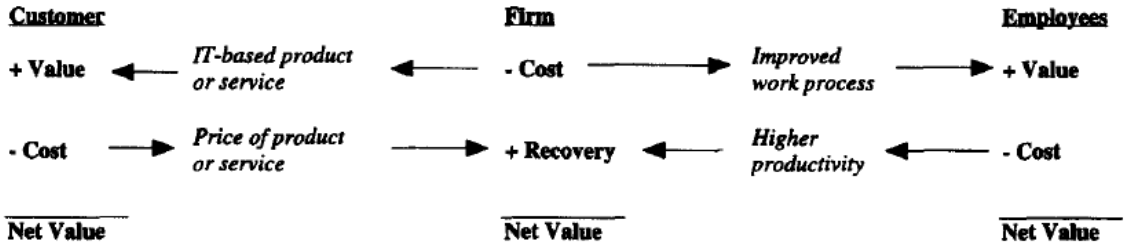

Figure 11. Stakeholder-Based Value Model (SBVM) (From Jurison, 1996)

1. Application to the MITSC and Department of Defense (DoD)

This model fits the role a Marine Air Ground Task Force (MAGTF) Information Technology Support Center (MITSC) and DoD play as "firms." As the operator of a regional data center, the MITSC makes investments in IT that has the aforementioned flow of benefits. First, it has employees that directly benefit from the investment in IT by allowing them to better manage the data center and its associated network support activities. Secondly, the operating forces are its main customer base that receives the benefits of IT to enable it in its performance of mission critical tasks. Similarly, within the Joint Information Environment (JIE), the DoD has requirements to serve a variety of different users with many needs. Overall, different MAGTF and DoD elements use IT to different degrees for a variety of purposes making it extremely difficult to measure benefits at an aggregate level.

2. Measuring Benefits

In order to measure benefits, Jurison (1996, p. 270) citing Keen (1991) persuasively argues that firms need a "set of operational indicators of IT performance, called anchor measures." These operational indicators reflect the benefits generated by IT

and the objectives internal to the business (Jurison, 1996). Anchor measures can also be extended to the various stakeholder groups. By extending these to different stakeholder groups, decision makers can more easily assess what it is worth to them individually. In other words, tracking stakeholder benefits through anchor measures may overcome the limitations associated with traditional financial managers and can allow managers to make better informed IT investment decisions (Jurison, 1996).

Establishing anchor measures would not be an easy task. Choosing anchor measures largely depends on the judgment of managers and the value each stakeholder plays in the mission of the organization it serves (Jurison, 1996). Valuing benefits of data center consolidation will require management to judge how each stakeholder group will benefit from it. Such measures as lower risk, greater control, better economies of scale, better utilization of power and resources can all be assigned a notional value in order to make this assessment. As introduced in Chapter II, market comparables offers a viable alternative for allocating revenue streams to similar outputs or processes found in the private sector. For example, if an organization has the ability to make an assessment of what similar services would cost on the open market, a market comparables approach to valuing the benefits of IT can be used as well.

C. DATA CENTER METRICS

In order to assess the efficiency and efficacy of a data center, key metrics are required for analysis. Data center metrics can also be used to assess alternative approaches to data center consolidation such as cloud computing. The FDCCI (2010) outlines the following program goals of consolidation by improving:

- Server (processor) Utilization (%)
- Rack Space Utilization (%)
- Rack Floor Utilization (%)
- Power Usage / Square Foot
- Power Usage Efficiency (PUE) (p. 4)

FDCCI (2010) also outlines in Figure 12 the four key impact areas that consolidation will achieve.

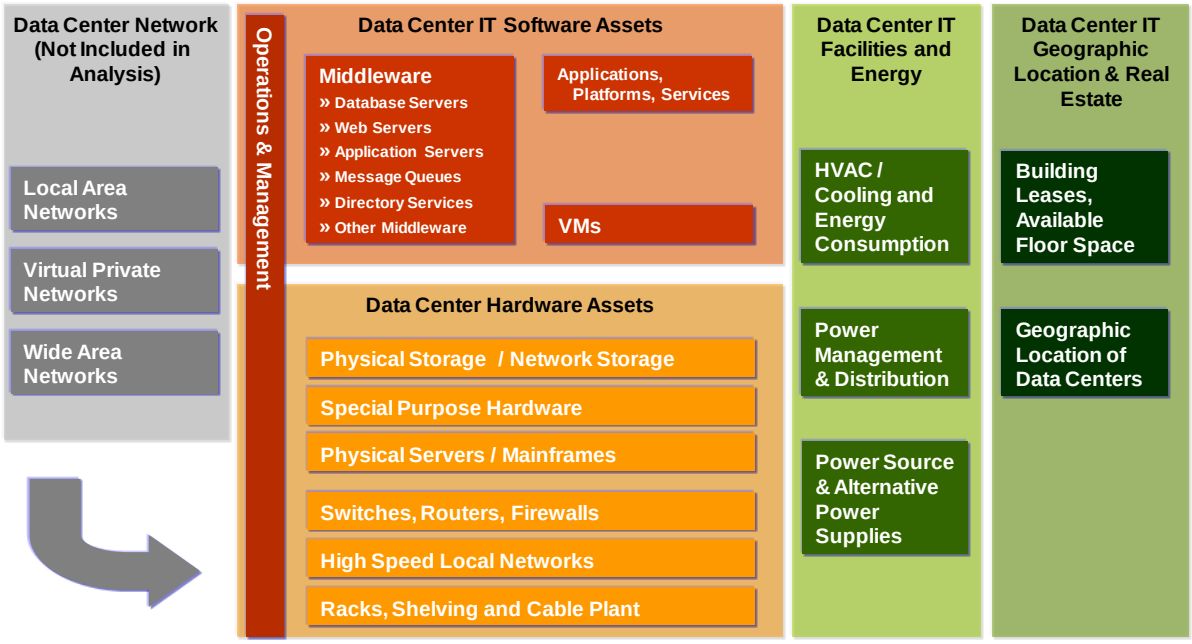

Figure 12. Agency Consolidation Plan Template (From FDCCI, 2010).

Alternatively, Winter (2009) states that processor load on Central Processing Units (CPU), main memory consumption of Random Access Memory (RAM), hard disk throughput (disk input/output (I/O)), and network throughput (network I/O) provide the adequate criteria for the selection of servers and their connections in a data center environment. The following criteria blend elements of FDCCI metrics and ones proposed by Winter (2009), with the addition of manpower cost.[8] The criteria are summarized as follows:

- CPU Utilization
- RAM Utilization
- Storage Utilization
- Network Throughput
- Rack Space Utilization
- Rack Floor Utilization
- Power Usage / Square Foot

[8] Personnel may remain even after consolidation because of contractual obligations and need to be taken into account as costs. Contractors may be part of certain programs of record and will need to manage those specific systems regardless of where they reside.

- Power Usage Efficiency (PUE) (p. 194)
- Manpower

Except for manpower, these criteria can also be used to baseline current costs and potential benefits of consolidation. The Open Group (2010) has also proposed three useful ratios that are normally used for evaluating cloud services, but are very applicable to estimating some aspects of data center efficiency. These address key issues in Data Center Infrastructure Management (DCIM).

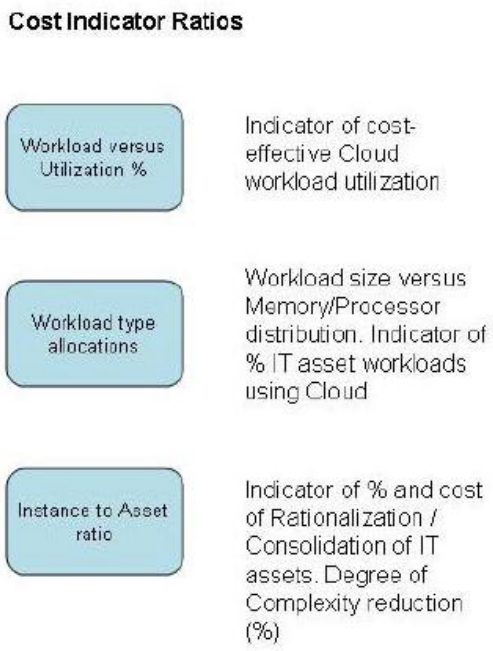

Figure 13. IT Cost ratios (From The Open Group, 2010).

By performing a comparison cost analysis that provides equal Quality of Service (QoS), security, and risk, a side-by-side comparison of ROI can then be conducted. Furthermore, it will enable an evaluation of the required capacity of long-haul optical carrier (OC) transmission requirements. For instance, a significant increase in bandwidth between data centers may also increase the cost of what agencies pay to the Defense Information Systems Agency (DISA) and or commercial carriers for DCC.

In order to effectively gather this data, the use of Network Management Software (NMS) will be required. Taking a physical inventory of network assets in not only impractical, it would not yield the convenient and efficient near real-time result a NMS can offer. NMS not only offers easy discovery of all networked equipment, but also provides how these assets are being utilized at an individual or an aggregated level. The level of detail provided by NMS greatly reduces the burden of managing the consolidation of data centers. By way of example, the Defense Information Systems Agency (DISA) has relied on a NMS product by Kratos Networks called Neural Star to manage the Global Information Grid (GIG) (Kratos, 2013). DISA uses Neural Star as the primary tool in its suite of Integrated Network Management System (INMS) software to manage the Defense Information Systems Network (DISN) (Kratos, 2013).

Relying on similar industry metrics may not provide the full picture of how a data center is used. Often, organizations need to define their own metrics in order to interpret how value is derived from a data center. In a lesson from the private industry, eBay recently published its own Digital Service Efficiency (DSE) metrics that define the best metrics that helped them understand how their data centers provide value (eBay, 2013). For eBay, the DSE makes the "connection to what the customers do on their websites and the total cost of providing services to them" (eBay, 2013, p. 1). Figure 14 details the metrics eBay used to develop the DSE while Figure 15 shows how the metrics can be viewed in real-time through a dashboard interface. This same methodology can be used by any organization to define the metrics that best express the costs and benefits of data center operations. Most importantly, such details can give decision makers insights into how efficient current data center operations are, which can directly influence decisions on DCIM and consolidation.

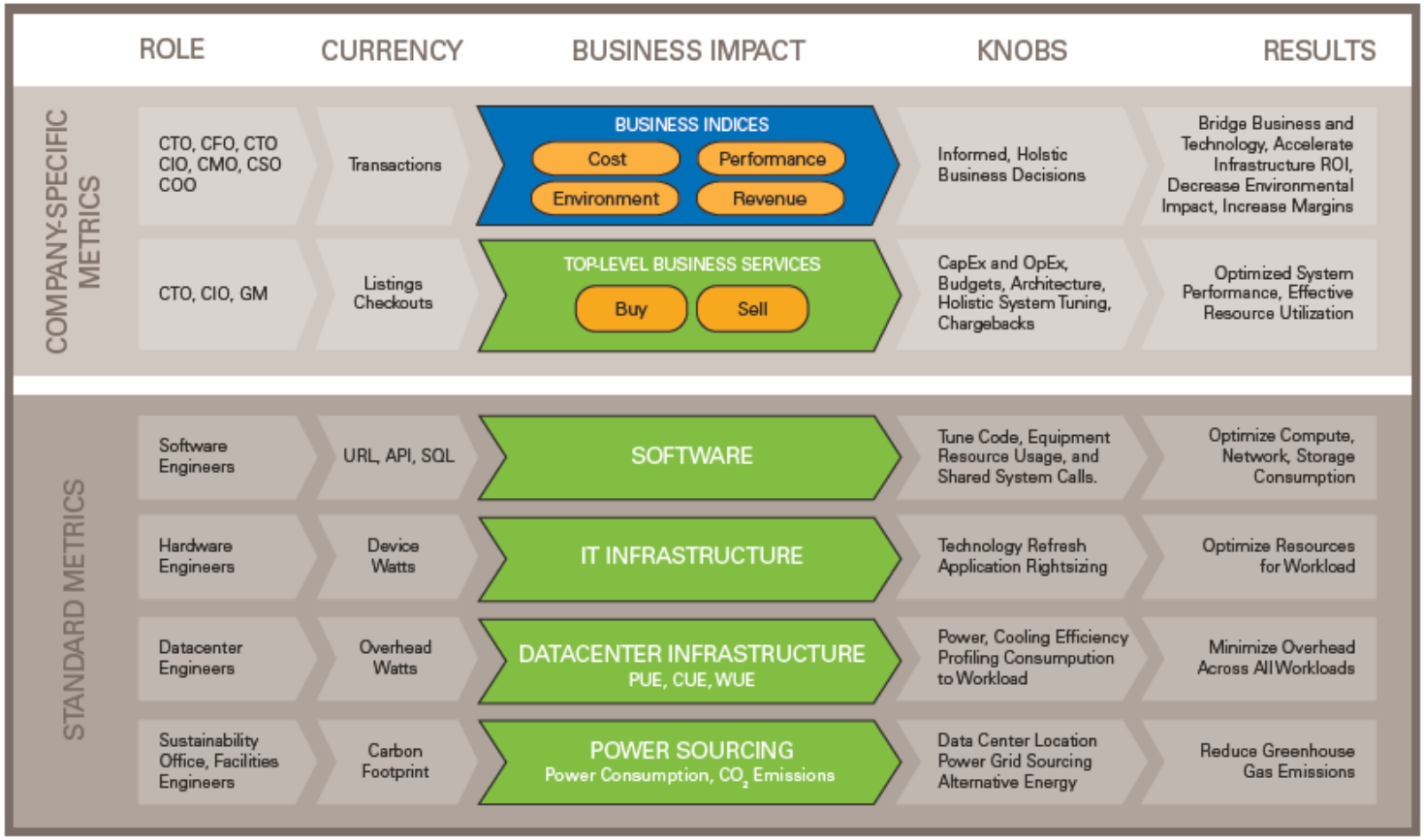

Figure 14. Data Center Efficiency Metrics (From eBay, 2013)

Figure 15. DSE Dashboard (From eBay, 2013)

Without the ability to discover and monitor resources on a network, making decisions of consolidation may prove fruitless. In the words of the late management guru Peter Drucker, "if you can't measure it, you can't manage it" (Singleton et al., 1988, 326). Put another way, without a method to systematically measure or baseline current performance, managers can only fall back on their own experience and judgment, which may not be sufficient (Singleton et al., 1988). This is especially true for data center consolidation that requires measured improvements in performance and utilization.

D. DATA CENTER CONSOLIDATION BEST BUSINESS PRACTICES

In order to assess the shortfalls in the DoD's, and more specifically the Marine Corps' Information environment, the most important business practices in data center consolidation from the Department of Technology Services (DTS) for the state of Utah are presented. This case study was used because it most closely resembled the characteristics of the MCI-W environment. For example, Utah DTS was responsible for seven diverse campuses across the state and each manages over 1,000 servers. While not perfect, this comparison offers similar challenges and complexity while furthering the

discussion on assessing the necessary improvements required to yield positive ROI for data center consolidation efforts.

1. State of Utah DTS Background

The state of Utah embarked on an ambitious data center consolidation initiative on 6 January 2009 (Utah, 2010). The project was completed in only 12 months with 6 months of pre-planning for a total project length of 18 months. The Utah DTS (2010) project achieved the following results:

- Reduced the number of data centers in the State from 35 to 2
- Reduced the total number of physical servers from 1864 to 591
- Saved the State $4 million annually ongoing in server, support, and energy costs
- Increased security
- Increased performance

These results were manifest in the following ways:

- 60% performance gain on a Data Warehouse batch job that is regularly run at the Department of Workforce Services
- Perceivable 30% performance increase at the Department of Health when accessing data files with outside entities

  Total runtime for State Payroll decreased from 39 hours to just 3.5 hours, and realized a cost avoidance of $300,000 in hardware (p. 3-4)

2. Utah DTS Approach to Consolidation

Utah DTS approached consolidation from the perspective that it could best be executed at the level closest to the customer (Utah, 2010). This approach allowed Utah DTS to assign individual project managers to each of the seven locations, which allowed each lead to handle the unique issues with each campus (Utah, 2010). The reporting structure for Utah DTS is given in Figure 16. This structure allowed Utah DTS to manage the project as a collection of seven smaller consolidations instead of one large project (Utah, 2010). Moreover, this disaggregation allowed each campus to work independently of each other; therefore, progress was made in parallel towards overall project goals (Utah, 2010). As a result, the project was completed within a significantly shorter timeframe (Utah, 2010).

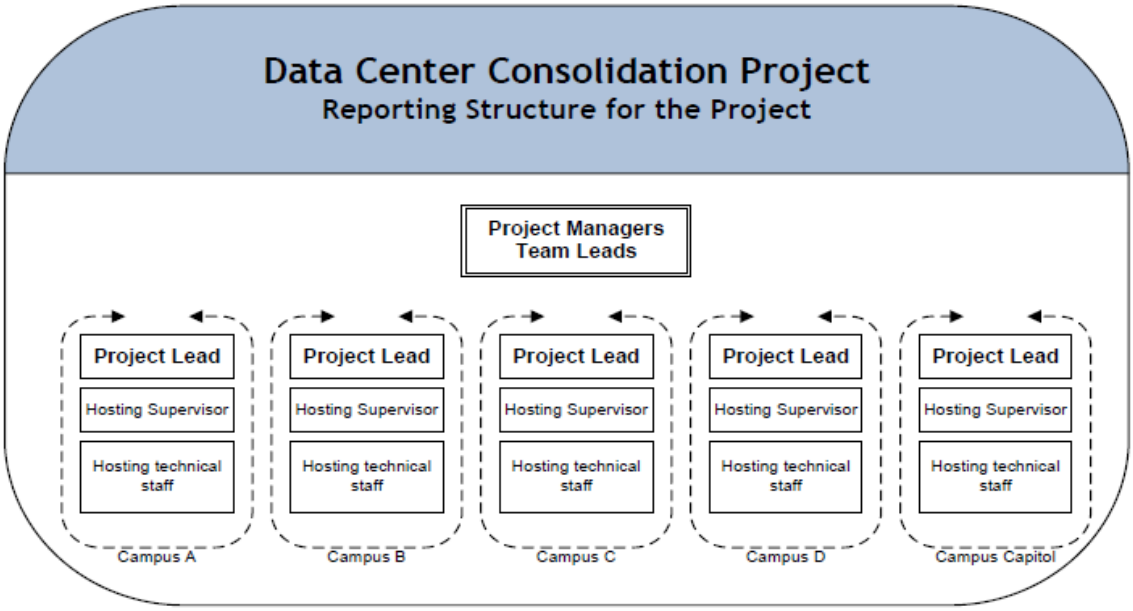

Figure 16. Utah DTS Reporting Structure (From Utah, 2010)

Even though Utah DTS managed each campus separately, they worked with each one through the planning process (Utah, 2010). Utah DTS also set up a team with representation from each campus to work the enterprise level issues. This setup also resulted in performing individual verifications of assets at each location. For instance, this verification process found an additional 164 servers that were not accounted for in the original assessment (Utah, 2010). This echoes similar findings by the GAO finding previously unaccounted for data centers. Most importantly verification of assets by Utah DTS before starting consolidation resulted in important architectural decisions that accounted for the increase (Utah, 2010).

3. Utah DTS Best Practices

The idea of best practices connotes the idea that other organizations may benefit from the application of this knowledge. This idea is also present in knowledge management, which provides a framework for applying structures and processes that enable individuals, groups, and organizational learning to occur more effectively (Gorelick & Tantawy-Monsou, 2005). This framework emphasizes that people, processes, and technology are integrated to increase learning and support organizational

performance (Gorelick & Tantawy-Monsou, 2005). Utah DTS's initial approach to consolidation recognized this aspect as well. Before embarking on this project, Utah DTS consulted with the states such as California and Oregon which conducted similar consolidations (Utah, 2010). They also partnered and consulted with industry in order to leverage consolidation expertise (Utah, 2010). Along similar lines, leveraging previous experience and expertise from other organizations can provide more robustness to the process. Indeed, the use of knowledge management with this framework can improve the Marine Corps' consolidation efforts to achieve a better ROI; therefore, the categories for these best practices are borrowed from this knowledge management framework. Table 4 categorizes these lessons appropriately under people, processes, and organization.

Table 5. Utah DTS Lessons Learned (After Utah, 2012, p. 13-14)

Category	**Lesson Learned**
People	Give each project group the responsibility to form their own plan and accountability for achieving the architected plan
	Regular communication is essential for a successful project
	Regular and consistent communication needs to exist between enterprise groups (e.g., hosting, storage, networking) and IT staff assigned to the campus
People	Ensure teams are being heard

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Category	Lesson Learned
People	Customer Communication - Maintain a high level of communication with the customer and the Campus IT manager about the project
	Ensure there are single points of contact for each of the functional areas of networking, storage, virtual environment, and data center
	Don’t rely on email as the sole source for communicating changes and requests for the project
	Ensure technical groups are committed to the project
	Ensure the organizational structure is aligned with project
	Executive support is essential to the success of the project
	Ensure the enterprise group has the hardware and people in place to handle the scaling of systems and resources that will need to occur
	Ensure that staffs have knowledge of a virtual server environment
	Judicious use of consultants to fill in the knowledge gaps

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Category	Lesson Learned
Processes	Ensure the project plan has clearly defined objectives and deliverables to prevent scope creep
	Break up the project into manageable parts and run the project as concurrent multiple projects instead of one consecutive project
	Give visibility to the progress of the project
	Ensure funding levels are appropriately identified for the project
	Identify processes of moving the hardware and communicate those moves to the enterprise groups
	Understand that even with good sound processes and adequate planning, tasks are going to be forgotten in a large-scale move, and technical teams will need to possess the agility to react to the situation
	Incident, problem, change and reliability management tools and processes should be in place prior to project initialization to prevent service level issues
	Not every campus can or should do their moves like the other campuses
	Set time frames for task completions to allow for application testing before/after server migrations

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Category	Lesson Learned
Technology	Create a Configuration Management Database (CMDB) of all equipment impacted by the project the first step in the project
	Virtualization is not a one solution fits all
	With complex systems, it was easier to *[go from physical to virtual (P2V)]* P2V than to migrate them. With simplistic systems, it was easier to migrate than to P2V.

While not exhaustive, this list provides some practical lessons that can be applied to DoD and Marine Corps consolidation efforts that can affect ROI. Indeed, standing up a task force for consolidation is a factor when calculating the upfront investment cost. As a result, their efficiency directly affects the overall ROI of the project. Moreover, these lessons provide a way for task forces to be more efficient and lower investment costs.

4. Industry Best Practices

The private sector also provides some key lessons learned in data center consolidation. For one such firm, consolidation provided an opportunity to modernize equipment, reduce complexity, enforce best practices, and improve overall performance and security (L. Trudel, personal communication, 12 July 2013). The following are some of the key lessons learned in this firm's efforts to improve the success of consolidation (L. Trudel, personal communication, 12 July 2013).

- Establish executive steering committee
- Work hand-in-hand with Facilities
- Start early (they started one year out for moving and planning)
- Address long-lead items first (e.g., carrier fiber) and manager risks

- Strong application support needed, and therefore business awareness
- Use staff augmentation if possible, with specialized skillsets
- Expect a higher number of outages due to the amount of change-prepare executives
- Use the data center move as an opportunity to do a clean-up
- Re-use what makes sense, but leverage higher capacity/density servers for space reduction and increased virtualization
- Conduct the consolidation in waves. Consolidation does not need to happen all at once

5. Government Sector Best Practices

Looking at agencies with similar reporting requirements to the DoD is also helpful. Several federal agencies have published best practices from their data center consolidation efforts. While most overlap in their recommendations of how to best use people, processes, and technology, the United States Department of Agriculture (USDA) stands out above the others in the details given. First, the USDA (2012) listed key members that composed the dedicated full-time staff for consolidation. They consisted of the following personnel (USDA, 2012):

- Program Lead
- Project Manager (2ea)
- Architect (2ea)
- Application Migration Specialist (3ea)
- Active Directory Engineer/Identity Manager
- Systems Administrator (2ea)
- Senior Security Engineers (2ea)
- Senior LAN/WAN Network Engineer (2ea)
- Senior DB Engineer (2ea)
- Business Lead (p. 4)

The USDA also broke down their approach to consolidation in four steps as summarized (USDA, 2012):

- **Initiation**:
  - Establish internal strategy and tactics - get all to buy in
  - Establish customer business relationships

- **Discovery**
  - Understand the customer business applications, environment and budgeted application plans
- **Planning**
  - Break application move into manageable pieces
- **Execution**
  - Ensure customer applications function in the new environment – parallel testing leading to production (p. 8)

Most importantly, the USDA (2012) listed the key tools required for a successful consolidation:

- **VMWare Capacity Planner (VMCP) -** a consolidation-assessment and decision-support tool used to build the best possible infrastructure virtualization plan. Capacity Planner automates the data collection and analysis of server resources and their performance and utilization profiles.
- **Atrium Discovery and Dependency Mapping (ADDM) -** Automatically discovers physical and virtual IT assets and application, and the relationships between them.
- **BladeLogic -** discovers a complete view of distributed, virtual, and mainframe environments, and creates visual mapping of IT infrastructure
- **Solar Winds** – discovers of network bandwidth & traffic patterns down to the interface level. Identifies which users, applications, & protocols are consuming the most bandwidth.
- **SysTrack** – used to ensure end-user experience management for "client-server" type applications slated to be migrated. The Tool performs user auditing, performance monitoring, latency and, application resource analysis, and application pool design (p. 6).

The lessons learned provided by the USDA are relevant to the DoD and MCI-W for several reasons. First, it demonstrates the need to assemble a team of experts that have a sole responsibility for consolidation, which avoids overtasking the current data center staff. Second, it highlights the need for specific tools that focus on discovery and network metrics, which supports key consolidation decisions.

6. Application

Overall, these lessons provide a way for data center task forces to identify gaps and shortfalls in their knowledge, skills, and tools that are required for effective data

center consolidation. Data center consolidation requires a depth and breadth of many different skills sets ranging from very technical to operations and financial management. To be sure, of all the lessons learned, most deal with people and the least deal with technology. As a result, assembling the right team with the correct skills should be one of the first tasks in any consolidation effort.

E. ASSESSING THE VALUE OF A DATA CENTER

The most significant challenge in evaluating investments in IT for the DoD is valuing the benefits it provides. Given the complex nature of data centers and the diversity of stakeholders it may serve, assessing ROI has proven challenging for many organizations, especially the DoD. The recent reports by the GAO (2013) have demonstrated that cost savings have proven elusive for data center consolidation; therefore, a new approach to evaluating the ROI for consolidation is proposed.

It was shown in this Chapter that the data center provides a variety of services to numerous stakeholders. In some instances, valuing the benefits at the stakeholder level may make the most sense as mentioned with the application of SBVM. For this reason, valuing the aggregate services a data center provides allows for an easy method to evaluating IT investments. As mentioned in Chapter 2, the application of market comparables can be used as a surrogate for revenue a similar data center would generate in the private or public sector for services rendered to a customer purchasing the similar services. For example, a DoD organization can use the Defense Information Systems Agency (DISA) rate card to value the services it provides to its own stakeholders (provided as Appendix A). Such an evaluation can serve a two-fold purpose. First, it can be used to as a way to measure the efficiency of data center services. In other words, if DISA can provide the same services for lesser cost, an evaluation of outsourcing to DISA may provide a more cost effective alternative to hosting it in-house. Second, the DISA rates can serve as a surrogate for revenue in the ROI equation to evaluate the efficiency of a data center before and after consolidation. While there may be limitations to using market comparables for comparing services such as finding equal comparisons and valuing the intangible capabilities a data center provides, it can however provide a richer understanding of evaluating the costs and benefits of consolidation.

F. SUMMARY

Transitioning to a Government Owned/Government Operated (GO/GO) model poses many challenges under the Marine Corps' Next Generation Enterprise Network (NGEN). Managing one of the largest networks in the world will require a great deal of skill. Breaking with the trends of most other Federal agencies' inability to realize returns on data center consolidation investments will require assessments that go beyond cost savings and cost avoidance alone. For this reason, this chapter recommended three important aspects that can help evaluate data center consolidation investments. Understanding how to assess value of a consolidation to the stakeholder level is important in assessing benefits because of the flaws inherent in aggregating at the macro level. Data center metrics are equally important in order to baseline current data center costs and measuring meaningful progress towards achieving a positive ROI. While principally technical in nature, data center consolidation efforts have been shown to be equally rooted in managing people and the processes. In order for the DoD and the Marine Corps to evaluate these investment decisions effectively, benefits, costs, and best practices will all need to be considered in order to paint the entire ROI picture.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. OVERVIEW

This chapter concludes this research by summarizing the challenges and recommendations for addressing the original research questions. Additional recommendations that may assist in understanding ROI for data center consolidations are also given that should be considered as part of the Analysis of Alternatives (AoA). Lastly, this chapter concludes with recommendations for future work in the area data center consolidation and challenges in assessing the current Marine Corps Information Environment.

B. CONCLUSIONS

1. Primary Research Question

What are the challenges in assessing the Return on Investment (ROI) for Department of Defense (DoD) Data Center Consolidation efforts?

The DoD has found itself at a nexus of two diametrically opposed problems. First, the discovery of additional data centers has more than doubled what the DoD originally assessed (Johnson, 2013). Second, the recent reports by the GAO (2013) show that cost savings from data center consolidation are not materializing as projected. These problems coupled with cuts in the DoD budget only make these problems worse and only raise more questions than answers.

The research herein has shown that a focus on cost savings and cost avoidance are widely misapplied to calculating ROI for data center consolidation. DoD's analysis will need to value the benefits received from consolidation using other means beyond cost savings and avoidance. Cost savings and cost avoidance are secondary benefits that will reduce and avoid costs in the future; therefore, they cannot be used to evaluate an investment decision in the present. Furthermore, the DoD lacks a method to value data center consolidation benefits and capabilities whether quantitatively or qualitatively, which makes it difficult to in assessing investment decisions.

The recommendations to understanding ROI for data center consolidation are summarized:

a. Accurate Discovery and Meaningful Metrics

DoD needs to ensure that agencies are employing modern network management software (NMS) for discovery of assets. Relying on static diagrams or Excel spreadsheet listings of network assets will not work effectively. NMS provides an automated way to discover all assets on the network, provide the necessary statistics to assess the utilization of circuits and servers on the network, and the ability to anticipate network issues before they become problematic or cause outages. Moreover, consolidation should not be a one-size-fits-all imperative. The DoD needs to consider additional metrics that also affect complexity of the data center, which may be an additional cost driver. Assessing a data center strictly quantitatively or qualitatively will most likely miss the intangible and tangible benefits, respectively and ignore the value proposition as a whole (Heydari, Damanpour, & Nassar, 2011).

b. Valuing Benefits and Capturing Cost

As mentioned, data center consolidation needs to look beyond cost savings and cost avoidance. Data centers often serve diverse stakeholder groups that value IT in different ways. For this reason, the DoD, and more specifically the Marine Corps, needs to look how each stakeholder leverages capabilities from the data center. The Stakeholder Based Value Model (SBVM) has the potential to allow such capabilities to be monetized and evaluated independently in order to assess ROI accurately and compare alternative approaches that provide similar capabilities. In the same vein, calculating ROI will be equally problematic if the total cost of running a data center is not captured correctly. Detailed metering of all assets, while expensive in and of itself is the only accurate way to assess the true costs of running a data center. Hence, relying on "average cost models" or theoretical extrapolations may not reveal the full burden cost of operating a data center.

c. Implementing Best Practices and Identifying Shortfalls

A thorough search for DoD lessons learned specific to data center consolidation yields little results. Yet, following the best practices of other agencies can save time in planning and execution as this knowledge is applied to similar situations. Developing a knowledge management portal for lessons learned has several potential

benefits. First, lessons learned that are specific to DoD in terms of acquisitions and IT security requirements can save time money by avoiding similar mistakes, while leveraging the knowledge gained from previous consolidation efforts. It can also help a consolidation task force ensure they have the right mix of staff, skills, and tools to accomplish the mission. If done correctly, lessons learned databases can ensure the best practices spread to the entire organization.

2. Secondary Research Question

Under the Next Generation Enterprise Network (NGEN), what are the current shortfalls in the Marine Corps' ability to assess its information technology investments?

The NGEN is a monumental undertaking by both the Marine Corps and the Navy. Evaluating investments in Information Technology (IT) requires a robust set of tools and a staff with many skills sets. More importantly though, it requires the metering of IT assets and facilities in order to establish an "as-is" baseline cost to operate. For instance, many buildings aboard Marine Corps bases are not metered at all, which makes it difficult to baseline energy costs with some degree of precision. Also, network operations are very dynamic and require a set of tools commensurate for the task. It is the assessment of this researcher that the shortfalls in the Marine Corps' ability to assess its information technology investments are no different than the DoD. Therefore, the recommendations to the primary research question are applicable here as well.

C. ADDITIONAL OBSERVATIONS AND RECOMMENDATIONS

1. Virtualization May Prove More Expensive

The Marine Corps Unification Campaign Plan states that "Fiscal constraints and operational requirements necessitates for the consolidation of resources by leveraging virtualization technology" (MCEN, 2013, p. 7). More specifically, the campaign plan states that the Marine Corps will help achieve cost savings by leveraging Virtual Desktop Infrastructure (VDI). However, a report by Microsoft (2010) found that VDI is more expensive than managing a traditional personal computer (PC) environment. Microsoft (2010) found that the higher costs in managing the software necessary to deploy VDI

outweighed the cost savings in other areas. Figure 17 shows that Windows XP and Windows 7 deployed in a VDI environment resulted in increased costs (Microsoft, 2010, p. 11). A white paper published by Information Systems Audit and Control Association (ISACA) (2012) also highlights the fact that VDI does provide many benefits, but also a number of risks, such as being a single point of failure. Preventing these failures only increases the cost of deploying VDI. As a counterpoint, this may not be true of all environments. For instance, Computer Sciences Corporation found that running 5,000 desktop computers compared to running 5,000 VDI instances actually reduced cost by 20 percent (Jackson, 2010, para. 7). As a result, the Marine Corps will need to weigh the risks, costs, and benefits of VDI and challenge the common assumptions that VDI will always result in cost savings.

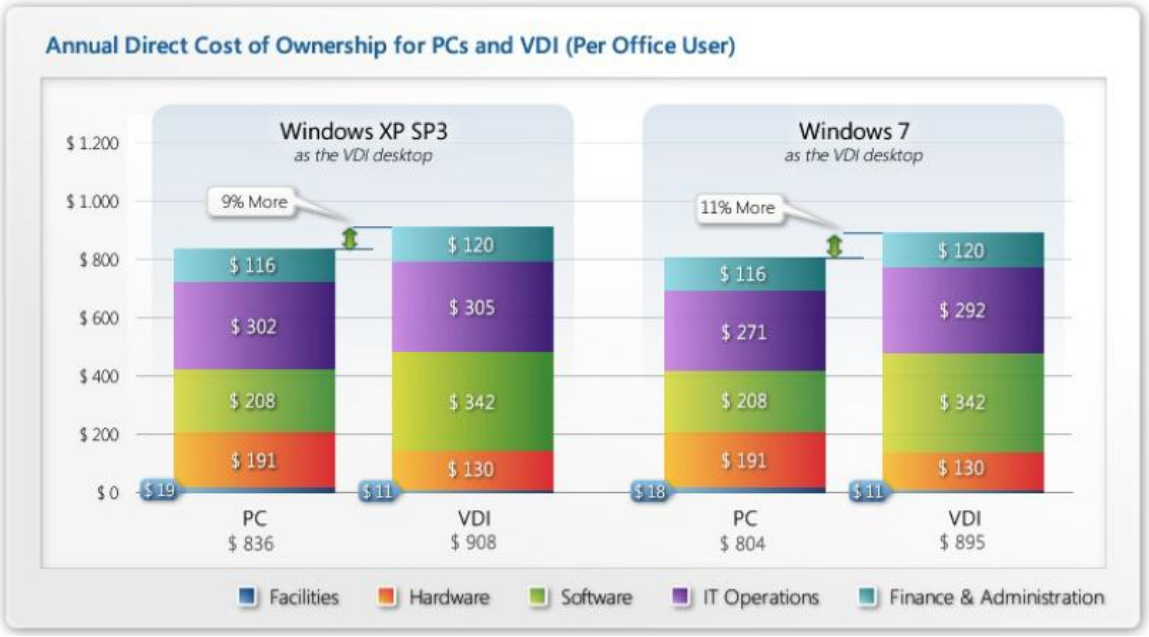

Figure 17. Cost Comparison of VDI versus PCs (From Microsoft, 2010)

2. The Relationship between Data Center Consolidation and Cloud Computing

This research revealed many similarities between data center consolidation and cloud computing. These similarities make cloud computing a viable alternative to data

center consolidation and should be considered in an AoA. A brief introduction, comparison, and the benefits of cloud computing are given below.

According to the National Institute of Standards and Technology (NIST) (2011) the cloud is defined as:

> A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (p. 2)

The cloud also offers three major services. These models are Software as a Service (SaaS), Infrastructure as a Service (IaaS), and Platform as a Service (PaaS). SaaS offers clients the ability to run a variety of common applications from the cloud, thus allowing the customer access through a web browser or thin-client (NIST, 2011). IaaS allows the customer to provision storage, networking, memory, and processing power as needed (NIST, 2011). PaaS allows the customer to provision servers, operating systems, and other hardware as required (NIST, 2011). These three service models generally rely on the virtualization of hardware in order to allow multiple customers/clients to access the same physical hardware. These architectures are typically controlled by a hypervisor that manages the provisioning and creation of resources on a physical server. As a result, servers and their associated networking hardware are utilized more efficiently.

The relationship between data center consolidation and cloud computing are significant. Data center consolidation seeks to gain efficiencies through reduced energy consumption, smaller real estate footprints, reduced cost of managing hardware and software licensing, increased IT security posture, and shift IT investments to more efficient computing platforms and technologies (Kundra, 2010). Whether it is private, public, or hybrid deployment models, cloud computing accomplishes the same net effects through the efficient pooling of resources. The cloud service that most closely resembles data center consolidation is IaaS. Table 6 summarizes these similarities.

Table 6. Comparison between Data Center Consolidation and Cloud Computing IaaS

Resource	Data Center Consolidation	Cloud Computing IaaS
CPU Utilization	Seeks to improve current utilization rates for CPU usage.	Improves utilization by pooling resources and provisioning as required
Real Estate	Too many inefficient data centers exist. Consolidation will reduce real estate footprint	Maximizes real estate usage and provides redundancy in off-site locations as needed
Memory Usage	Seeks to improve current utilization of memory	Improves utilization by pooling resources and provisioning as required
Storage Usage	Seeks to improve current utilization of storage	Improves utilization by pooling resources and provisioning as required
Personnel	Consolidation will reduce the number of personnel required to operate data centers	Less manning required through hypervisors and autonomous software
Security	Improve overall security of the infrastructure, the applications, and data.	Fewer facilities with higher security. Faster deployment of patches and updates through virtualization technology
Energy Usage	Reduce energy costs through better utilization, greening of IT, more efficient data center layouts, and lower overall power consumption	Virtualization and autonomous energy management optimizes assets to function only when needed; optimal load balancing of equipment to promote energy savings

Additionally, cloud computing also provides significant advantages over traditional capital purchases of data center assets. Figure 18, shows how cloud computing can adapt to changes in usage and provide the optimal mix of services as they are requested more efficiently. This method is also viewed as transferring costs from capital expenses (CAPEX) to operating expenses (OPEX) (Armbrust et al., 2010). It saves time and money given that government acquisitions are often cumbersome and slow. For instance, government agencies typically forecasts what they will need and purchases extra capacity for anticipated growth to compensate for the slow speed of the acquisitions process. This methodology results in periods of over-utilization and under-utilization

because requirements are often unpredictable. Many analysts also say that cloud computing can deliver cost savings by "as much as three to five times cheaper than in-house data centers and hosted applications" (Wyld, 2009, p. 12). In a recent interview with John Wallerich (2013), a data center design and efficiency consultant, opined that there is no real difference between a data center and a cloud, only a difference in how it is used. In another way, cloud computing services can provide a market comparables methodology in order to provide a surrogate for data center revenue. Truly, cloud computing provides an analogous approach that emulates the goals of data center consolidation and should be considered in an AoA.

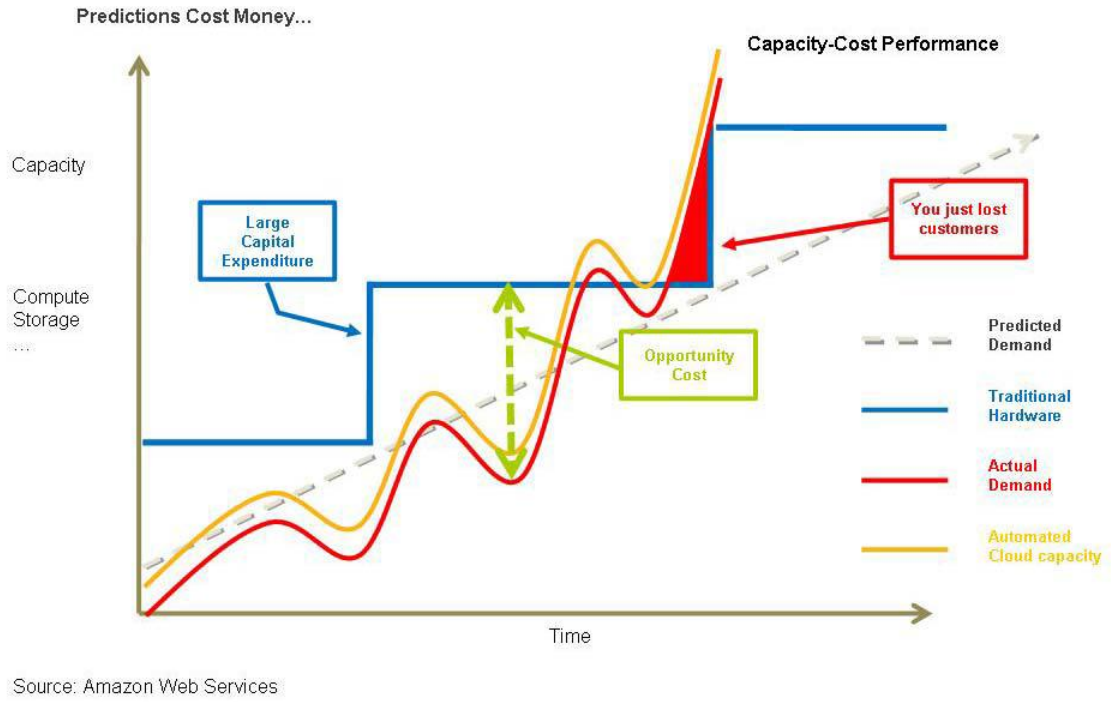

Figure 18. Capacity- Cost Performance of Cloud Computing
(From The Open Group, 2013)

D. RECOMMENDATIONS FOR FUTURE WORK

The following recommendations for future work can help extend the knowledge in the area of understanding the challenges in evaluating IT investments within the DoD. Likewise, with the transition to a Government Owned/Government Operated (GO/GO) model and a regionalization construct, the Marine Corps faces additional challenges with

preparing for the future Joint Information Environment (JIE). These efforts will require significant research and new approaches to address the many challenges

1. Backsourcing

Organizations have a variety of reasons why outsourcing IT can give them a competitive advantage. Yet, when the arrangement is no longer viable for reasons such as cost, security or Quality of Service (QoS), an organization may want to consider managing its own resources. Bringing back IT resources to in-house operations following an outsourcing arrangement is called backsourcing (Whitten & Leidner, 2006). With the backsourcing process already underway for the Marine Corps' Enterprise Network (MCEN), still many services, policies, and procedures will require creation since these were formerly administered under the NMCI contract at an enterprise level. The following questions are posed: In order to allow the Marine Corps to evaluate its future investments in IT, what policies, procedures, and tools should the Marine Corps pursue? What are some of the most important concerns when backsourcing a network. What are the seams, gaps, and strengths within future Installation Information Environments?

2. Supporting the JIE

The MCEN strategy also requires that efforts influence the development of the Joint Information Environment (JIE) (MCEN, 2013). These efforts will also influence consolidation strategies and their potential value. By advocating a more simplified strategy that merges multiple programs into a more cohesive whole, economies of scale can be leveraged and infrastructure can be shared across internal DoD boundaries; therefore the following question is posed: How should Installations transition from the existing strategy of the independent programs towards blending into shared infrastructure/services Joint Base Information Environment?

3. Return on Capabilities

Many of the most important capabilities within an organization are rarely quantifiable with traditional financial measurements such as ROI. This is especially true in the DoD because of many of the measurements that private sector firms use are non-

existent or difficult to monetize. What may be required is an entirely new measurement that takes a qualitative approach to comparing return on capabilities (ROC). A ROC could align with current DoD strategy for requirements and capabilities assessment under the Joint Capabilities Integration and Development System (JCIDS) process. Such a method could be developed that weights capabilities based on standard developed criteria in order to compare the returns on current capabilities and future investments.

E. SUMMARY

The DoD and its agencies face many challenges in understanding data center consolidation. It was the aim of this research to show the difficulty in understanding ROI and recommendations that will further research in the area of defining more meaningful metrics for data center consolidation. Future plans evaluating the benefits that data center consolidation provides will need to go beyond cost savings/cost avoidance and value the capabilities it affords. Future work in developing a return on capabilities seems appropriate. Assessing the alternatives to data center consolidation needs to be a part of the overall discussion to ensure the DoD is receiving the best value for its IT dollars.

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APPENDIX A. DISA RATE CARD

Enterprise Services Division

FY 2013 RATES

(Rates in Dollars)

IBM Mainframe	RATES
CPU Hours (per Hour)	$460.7676
Linux (per Hour)	$28.4401
Unisys Mainframe	
SUPS (per Hour)	$13.1771
Unisys Storage (MB/Day)	$0.0192

Enterprise Services	RATES
DoD Enterprise Email (per Account/Year)	$39.64
DEE Mobile (Blackberry only - per Device/Year)	$35.40

Storage (Monthly)	RATES
IBM Storage (MB/Day)	$0.0003
IBM Long Term Storage (MB/Day)	$0.0002
Server Basic Local (GB/Month)	$1.7889
Server Basic Remote (GB/Month)	$0.7214
Server Operational Local (GB/Month)	$0.7680
Server Operational Remote (GB/Month)	$1.7990
Server High Availability Local (GB/Month)	$1.1896
Server High Availability Remote (GB/Month)	$2.4107
Server Non-Disruptive Local (GB/Month)	$2.2800
Server Non-Disruptive Remote (GB/Month)	$3.2673
Server Tier 2 Basic Local (GB/Month)	$1.5563
Automated Time & Attendance Production System (per Account/Year)	$16.37

Server (Monthly)	RATES				
Operating Environment (OE)					
SERVER BASIC	*Level 2*	*Level 3*	*Level 4*	*Level 5*	*Level 6*
	$1,260	$2,048	$2,264	$2,450	$8,109
H/W SERVICES	*Level 2*	*Level 3*	*Level 4*	*Level 5*	*Level 6*
X86	$125	$337	$562	$3,546	
Non X86	$936	$1,544	$3,093	$7,936	$18,977
Additional Services					
Application Support	$1,285				
Database Administration	$1,681				
24 x 7 Services	$1,395				
Database S/W	*Level 2*	*Level 3*	*Level 4*	*Level 5*	*Level 6*
	$588	$2,699	$5,529	$6,201	$13,445

Figure 19. Enterprise Services Division FY 2013 Rates (From DISA, 2013)

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